The Piercebridge Formula in the North-east of England: an assessment and alternative method of supply to the Roman army

James D Anderson

Department of Archaeology,
University upon Newcastle on Tyne
November, 1991

This thesis is submitted for the partial fulfillment of the requirements for the Degree of Doctor of Philosophy

NEWCASTLE UNIVERSITY LIBRARY

091 51672 1

Thesis L3989

ABSTRACT

This thesis tests a recent theory of Roman military supply in the North-east of England. The Piercebridge formula (Selkirk, 1983) involves a system of Roman forts provisioned by barges along rivers made navigable by a series of dams, locks and canals. The formula is first assessed on a theoretical basis: as a comprehensive road system was built across Britain during the Conquest period, construction of Piercebridge formula components for river-borne fort supply would have been justified only if the Piercebridge formula was significantly more efficient than overland transport. To this end, the efficiency of Piercebridge formula river-borne fort supply vis-á-vis the efficiency of overland fort supply is assessed in a survey area comprising the North-east of England. Evidence for the 'formula' is then assessed at ten sites across the North-east.

A second aim of this thesis is to present an alternative to the Piercebridge formula method of supply to forts in the North-east. This alternative method involves sea-borne transport to ports serving the North-east, overland transport by ox-cart and pack animals along the Roman as well as native road systems, and river transport upon barges and other craft when such rivers were naturally navigable.

ACKNOWLEDGMENTS

I could not have managed this work without the assistance and support of many people. Advice from mentors such as Charles Daniels, Kevin Greene, John Chapman, and Paul Bidwell has been invaluable. The support of colleagues and friends such as David Cowley, Richard Willis, Richard Carlton, Alan Rushworth, Dave Edwards, Nick Hodgson, Dave Passmore, Denise Henley, Pat Suthern, and Mike Bishop, in the field, lab, office, and through correspondence has been much appreciated. I am also indebted to technicians and specialists for the following: John Law's computer assistance, John Dore's and Kevin Greene's pottery advice, Graham Morgan's mortar analysis, Dr Titman's geo-physical guidance, Gaynor Cummins' and Dave Passmore's geo-morphological expertise, Ian Christianson's hydrological information, and Robin Birley's comments on Vindolanda.

I also wish to thank various landlords and landladies for permission to excavate and/or survey their respective properties: the Viscount Lord Allendale of Bywell Hall, Mr and Mrs Gavin Reed of Broadgate Farm above Risingham fort, Mr and Mrs Hugh Fenwick of Brinkburn High Cottage, and Mrs Cussins of Low Learchild estate. In addition, the scientific work could not have been accomplished without funding and logistical support.

Radio-carbon dates at Risingham, Corbridge, Binchester, and Brinkburn were made possible by grants from the Society of Antiquaries of Newcastle upon Tyne, and Mr D M Anderson, while the geo-physical surveys at Risingham and Brinkburn were made possible by grants from the above-mentioned Society and the Excavation and Fieldwork Committee of the Universities of Durham and Newcastle upon Tyne. The geo-physical and geo-morphological equipment used in the field was borrowed from the Departments of Geo-physics and Geography, respectively, at the University of Newcastle upon Tyne.

Furthermore, I am grateful to Fred Coupland, Paul Bidwell, Steve Speak, and Ray Selkirk for granting permission to read their unpublished material. Fred Coupland's unpublished BA dissertation entitled The Piercebridge Formula: an Appraisal (1987), provided many insights into four sites covered in this thesis. Paul Bidwell's and Steve Speak's forthcoming article entitled "The Roman fort at South Shields: the excavations of the Headquarters Building and the South West Gate" represents the 'cutting edge' of scholarship dealing with the supply base at South Shields. Ray Selkirk's forthcoming article entitled "The Roman Jetty at Corbridge" supplements evidence for the Piercebridge formula at Corbridge.

This thesis was written in its entirety on a mainframe computer using Textform word processing facilities at the University of Newcastle upon Tyne, and cites work published for the most part before January, 1991.

CONTENTS

ABSTRACT ii

ACKNOWLEDGMENTS iii

1 INTRODUCTION 1

1.1 The Survey Area: the North-east 3

2 THEORY 7

2.1 Piercebridge formula river transport efficiency 8

2.1.1 Construction of static barriers 8

2.1.2 Maintenance of river systems with static barriers . . 13

2.1.3 Negotiation of Static Barriers: Lifting Devices . . . 29

2.1.4 Discussion 35

2.2 Overland Transport Efficiency 37

2.2.1 Distance 38

2.2.2 Load 42

2.2.3 Cost 52

2.2.4 The Character of Roman Roads 56

2.2.5 Discussion 58

2.3 Conclusion: Theory 60

3 EVIDENCE: AREA 1 62
3.1 Piercebridge 63
3.1.1 Evidence Supporting the Piercebridge formula 64
3.1.2 Evidence Refuting the Piercebridge formula 69
3.1.3 Conclusion 79
3.2 Chester-le-Street 81
3.2.1 Evidence Supporting the Piercebridge formula 82
3.2.2 Evidence Refuting the Piercebridge formula 85
3.2.3 Conclusion 93
3.3 Binchester 93
3.3.1 Evidence Supporting the Piercebridge formula 94
3.3.2 Evidence Refuting the Piercebridge formula 95
3.3.3 Conclusion 106

4 EVIDENCE: AREA 2 107
4.1 South Shields 108
4.1.1 Evidence Supporting the Piercebridge formula 109
4.1.2 Evidence Refuting the Piercebridge formula 121
4.1.3 Conclusion 125
4.2 Bywell 127
4.2.1 Evidence Supporting the Piercebridge formula 127
4.2.2 Evidence Refuting the Piercebridge formula 130
4.2.3 Conclusion 142
4.3 Corbridge 143
4.3.1 Evidence Supporting the Piercebridge formula 143
4.3.2 Evidence Refuting the Piercebridge formula 144

4.3.3 Conclusion 148
4.4 Vindolanda 149
4.4.1 Evidence Refuting the Piercebridge formula 150
4.4.2 Conclusion 155

5 EVIDENCE: AREA 3 157
5.1 Risingham 158
5.1.1 Evidence Supporting the Piercebridge formula 159
5.1.2 Evidence Refuting the Piercebridge formula 160
5.1.3 Conclusion 177
5.2 Brinkburn 179
5.2.1 Evidence Supporting the Piercebridge formula 179
5.2.2 Evidence Refuting the Piercebridge formula 182
5.2.3 Conclusion 195
5.3 Low Learchild 196
5.3.1 Evidence Supporting the Piercebridge formula 196
5.3.2 Evidence Refuting the Piercebridge formula 197
5.3.3 Conclusion: Low Learchild 207
5.4 Conclusion: Evidence for the Piercebridge formula 208

6 AN ALTERNATIVE METHOD OF SUPPLY TO FORTS IN THE NORTH-EAST . . . 213
6.1 Sea-borne Transport 214
6.1.1 Origin of Supplies: Ports 215
6.1.2 Merchant Shipping 234
6.1.3 Destination: Ports serving the North-east 249
6.1.4 Discussion 257

6.2 Road Transport 259

6.2.1 Origin: Ports serving the North-east 261

6.2.2 Origin: South Britain 275

6.2.3 Origin: Local Supply 277

6.2.4 Discussion 296

6.3 River Transport 297

6.3.1 Navigation below the tidal limits 302

6.3.2 Navigation above the tidal limits 311

6.3.3 Discussion 317

6.4 Conclusion: an alternative method of supply 319

7 GENERAL CONCLUSIONS 321

Appendix A : MILITARY STRENGTH IN THE 3RD CENTURY NORTH-EAST . . . 325

Appendix B : A ROMAN PERIOD DAM IN THE NORTH-EAST 328

Appendix C : ALLUVIATION IN THE ANCIENT WORLD 332

Appendix D : CULTIVATION IN THE NORTH-EAST 335

Appendix E : A ROMAN PERIOD POUND-LOCK? 345

Appendix F : THE LEWIS-HOLE AS DATING EVIDENCE IN THE NORTH-EAST . 358

Appendix G : LITERARY EVIDENCE FOR THE PIERCEBRIDGE FORMULA ACROSS

THE EMPIRE 361

Appendix H : GRAIN SUPPLY IN THE NORTH-EAST DURING THE ROMAN PERIOD 376

Appendix J : THE NATURE AND FUNCTION OF THE DEVIL'S CAUSEWAY . . . 390

Appendix K : THE LOGISTICS OF RIVER NAVIGATION ABOVE THE TIDAL LIMITS 401

Appendix L : HISTORICAL PARALLELS TO ROMAN PERIOD RIVER TRANSPORT IN THE NORTH-EAST 405

ANCIENT SOURCES 413

MODERN SOURCES 418

FIGURES

Facing Page

Figure 1: Places named in text. 1

Figure 2: The North-east. 3

Figure 3: Piercebridge. 63

Figure 4: Piercebridge According to Selkirk. 64

Figure 5: The second Dere Street bridge platform. 74

Figure 6: Chester-le-Street. 81

Figure 7: Chester-le-Street OS map, 1856. 83

Figure 8: RIB 1049. 83

Figure 9: Binchester. 93

Figure 10: Stratigraphy of core at Binchester. 96

Figure 11: The Location of South Shields Roman Fort. 108

Figure 12: Period 4 Antonine fort at South Shields. 111

Figure 13: Period 5 Severan fort at South Shields. 112

Figure 14: Period 6 post-Severan fort at South Shields. 114

Figure 15: Period 7 4th century fort at South Shields. 117

Figure 16: Bywell. 127

Figure 17: Bywell elevation showing 'By-pass Canal'. 133

Figure 18: Episodic cycle of Bywell flood plain. 134

Figure 19: OS Map of Bywell, 1862. 135

Figure 20: Map of Bywell, 1910. 135

Figure 21: Armstrong's Map of Bywell: 1769. 137

Figure 22: Map of Bywell: 1819; 1817-1856. 137

Figure 23: Plan of Bywell weir. 140

Figure 24: Section of Bywell weir. 140

Facing Page

Figure 25: Corbridge. 143

Figure 26: 'Roman jetty'. 144

Figure 27: Corbridge: Armstrong, 1769. 147

Figure 28: Corbridge: Woolley, 1907. 147

Figure 29: Catterick to Vindolanda via river system. 153

Figure 30: Catterick to Vindolanda via road. 154

Figure 31: Supply to Vindolanda from Kirkbride by river. 155

Figure 32: Supply to Vindolanda from Kirkbride by road. 155

Figure 33: Vindolanda to Binchester via river. 156

Figure 34: Vindolanda to Binchester via road. 156

Figure 35: Risingham. 158

Figure 36: Selkirk's Risingham. 159

Figure 37: RIB 1225. 159

Figure 38: Plan of Risingham fort by Bell, 1844. 160

Figure 39: Exploded plan of Bell's Risingham. 160

Figure 40: Valley floor morphology at Habitancum. 161

Figure 41: Schematic cross-section of valley floor at Habitancum. 162

Figure 42: Area of Excavation, Risingham. 164

Figure 43: Section of Trench 1, Risingham. 165

Figure 44: Pottery from Trench 1, Risingham. 166

Figure 45: Section of Trench 2, Risingham. 167

Figure 46: Risingham: OS, 1862. 171

Figure 47: Risingham: OS, 1896. 171

Figure 48: Geo-physical examination across Rede flood-plain. 172

Figure 49: Risingham Resistivity: Grid One. 173

Figure 50: Risingham Magnetometry: Grid One. 174

Facing Page

Figure 51: Risingham Resistivity: Grid Two. 175

Figure 52: Risingham Magnetometry: Grid Two. 175

Figure 53: Risingham Resistivity: Grid Three. 177

Figure 54: Brinkburn. 179

Figure 55: Brinkburn According to Selkirk, 1986. 180

Figure 56: Brinkburn Priory Bridge Sketch. 182

Figure 57: Brinkburn Trench 2 Plan. 183

Figure 58: Brinkburn Trench 2 Section. 184

Figure 59: Brinkburn Trench 1 Plan. 186

Figure 60: The Brinkburn Priory area: MacLauchlan, 1864. 192

Figure 61: Brinkburn: OS map of Brinkburn Priory area, 1896. 192

Figure 62: Geo-physics on Brinkburn Priory promontory. 193

Figure 63: Brinkburn Resistivity, Grid One. 194

Figure 64: Brinkburn Gradiometry, Grid One. 195

Figure 65: Low Learchild. 196

Figure 66: Aln Survey, Stage One. 199

Figure 67: Aln Survey: Stage Two. 202

Figure 68: Aln Survey: Stage Three. 203

Figure 69: Coe Burn Survey. 206

Figure 70: Thematic sketch: ports and routes of supply. 214

Figure 71: Distribution of Samian ware kilns. 220

Figure 72: Blackfriars ship. 237

Figure 73: County Hall ship. 237

Figure 74: BB Ware in the Frontier Area. 247

Figure 75: BB Ware Distribution across Britain. 247

Figure 76: Supply from ports overland to North-east. 259

Facing Page

Figure 77: Plan showing 1st of two large granaries at Corbridge. .272

Figure 78: Plan showing 2nd of two large granaries at Corbridge. .273

Figure 79: Hasholme Log-boat. 303

Figure 80: Brigg Log-boat. 303

Figure 81: The evolution of the dug-out, or log-boat. 304

Figure 82: Longitudinal Section of River Tyne bed in 1860. 310

Figure 83: Steering oar. 312

Figure 84: Possible Boat hook. 312

Figure 85: Section through dam at Lanchester. 328

Figure 86: Pollen diagrams in the North-east. 335

Figure 87: Cord-rig sites in the North-east: Areas 2 and 3. 337

Figure 88: Housesteads: Roman period cultivation terraces. 339

Figure 89: Cord-rig fields on Hut Knowe north, Northumberland. ...342

Figure 90: Iron Gates. 345

Figure 91: The region of the proposed Bithynian canal. 346

Figure 92: The region of the proposed Saône-Moselle canal. 346

Figure 93: The lewis-hole: Hero. 358

Figure 94: The lewis-hole: Landels, Gille. 358

Figure 95: Devil's Causeway. 390

Figure 96: Ptolemy's Map of Britain. 395

Figure 97: Settlements in the Tyne- Forth area. 396

Figure 98: Low Learchild site. 399

Figure 99: Flotation Bladder on Medallion. 402

Figure 100: Heronbridge: stone buildings, Hadrianic and later. ...403

PLATES

Facing Page

Plate 1: Site of 'second Roman bridge' at Piercebridge. 67

Plate 2: 'Bridge abutment'; 'Causeway'. 67

Plate 3: Masonry in upper and lower 'pound-locks'. 69

Plate 4: Masonry in barrack block.. 69

Plate 5: Bottom 'pound-lock', Piercebridge. 70

Plate 6: Mill-race and Medieval mill site. 70

Plate 7: 'Barge passing place', Piercebridge. 71

Plate 8: Meander in 'barge passing place', Piercebridge. 71

Plate 9: Artefacts found in River Tees, Piercebridge. 77

Plate 10: 'Barge harbour', Piercebridge. 79

Plate 11: 'Barge Harbour' at Binchester. 95

Plate 12: Sample cored from 'Barge Harbour'. 95

Plate 13: Channel I at Binchester. 103

Plate 14: Channel II at Binchester. 103

Plate 15: Stone in River Wear. 105

Plate 16: Stone with Lewis-hole, St Andrew's Church, Bywell. 128

Plate 17: St Andrew's Church, Bywell, with 'sounding holes'. 128

Plate 18: Masonry at top of back-channel. 129

Plate 19: Back channel. 136

Plate 20: Tyne's gravel bed and point bar. 136

Plate 21: Channel in ridge and swale surface of point bar. 138

Plate 22: Outlet of channel in ridge and swale. 138

Plate 23: Engraving of Bywell Bay, 1774. 139

Plate 24: Engraving of Bywell Bay, 1834. 139

Facing Page

Plate 25: Bywell weir, crest blocks, glacis, and end blocks. 141

Plate 26: Bywell weir masonry chamber. 141

Plate 27: Extraction of timber sample. 144

Plate 28: Timber from Corbridge 'Roman jetty'. 145

Plate 29: Paving in Corbridge 'Roman jetty'. 146

Plate 30: West aspect of north rampart, Risingham. 163

Plate 31: The 'groyne', Risingham. 163

Plate 32: Section of Trench 1. 168

Plate 33: Feature in south aspect of west baulk of Trench 1. 168

Plate 34: Overview of Trench 2 facing west. 169

Plate 35: Partial section of Trench 2 facing east. 169

Plate 36: Masonry in Chesterhope Burn. 170

Plate 37: Dere Street 'embankment' at Risingham. 170

Plate 38: Risingham: oblique view from north. 178

Plate 39: Tooled stone under Brinkburn bridge abutment. 181

Plate 40: Hollow-way on south bank of Brinkburn bridge. 181

Plate 41: Overview of Trench 2 at Brinkburn facing north. 185

Plate 42: Overview of Trench 2 at Brinkburn facing south. 185

Plate 43: Aln Valley at Jenny's Lantern. 197

Plate 44: River Aln near mouth. 198

Plate 45: Lesbury mill weir. 200

Plate 46: Lesbury mill race. 200

Plate 47: Stepping Stones at NU 218 118. 201

Plate 48: Boulders in Aln. 201

Plate 49: Abberwick mill. 204

Plate 50: Probable Rock dump on right bank of Aln. 204

Facing Page

Plate 51: Bolton mill. 205

Plate 52: Mouth of the Coe Burn. 205

Plate 53: Coe Burn at NU 09060 1260. 207

Plate 54: Coe Burn 50m down from Low Learchild fort. 207

Plate 55: Stones in line across Coe Burn. 208

Plate 56: Another line of stones across Coe Burn. 208

Plate 57: Zwammerdam 6. 304

Plate 58: Second Canoe, Pommeroueil, Holland. 305

Plate 59: First barge, Pommeroueil, Holland. 305

TABLES

Facing Page

Table 1: Piercebridge formula dam quantity and distribution. 10

Table 2: Road Transport Distances in the North-east. 261

Table 3: The Younger Fill. 332

Table 4: Numerical Estimates for Military Animals in the North-east. 377

Table 5: The amount of land under cultivation necessary to meet the grain demands of the army and native population in the North-east in the Roman period. 381

Table 6: Land under cultivation in the North-east in June, 1990. .385

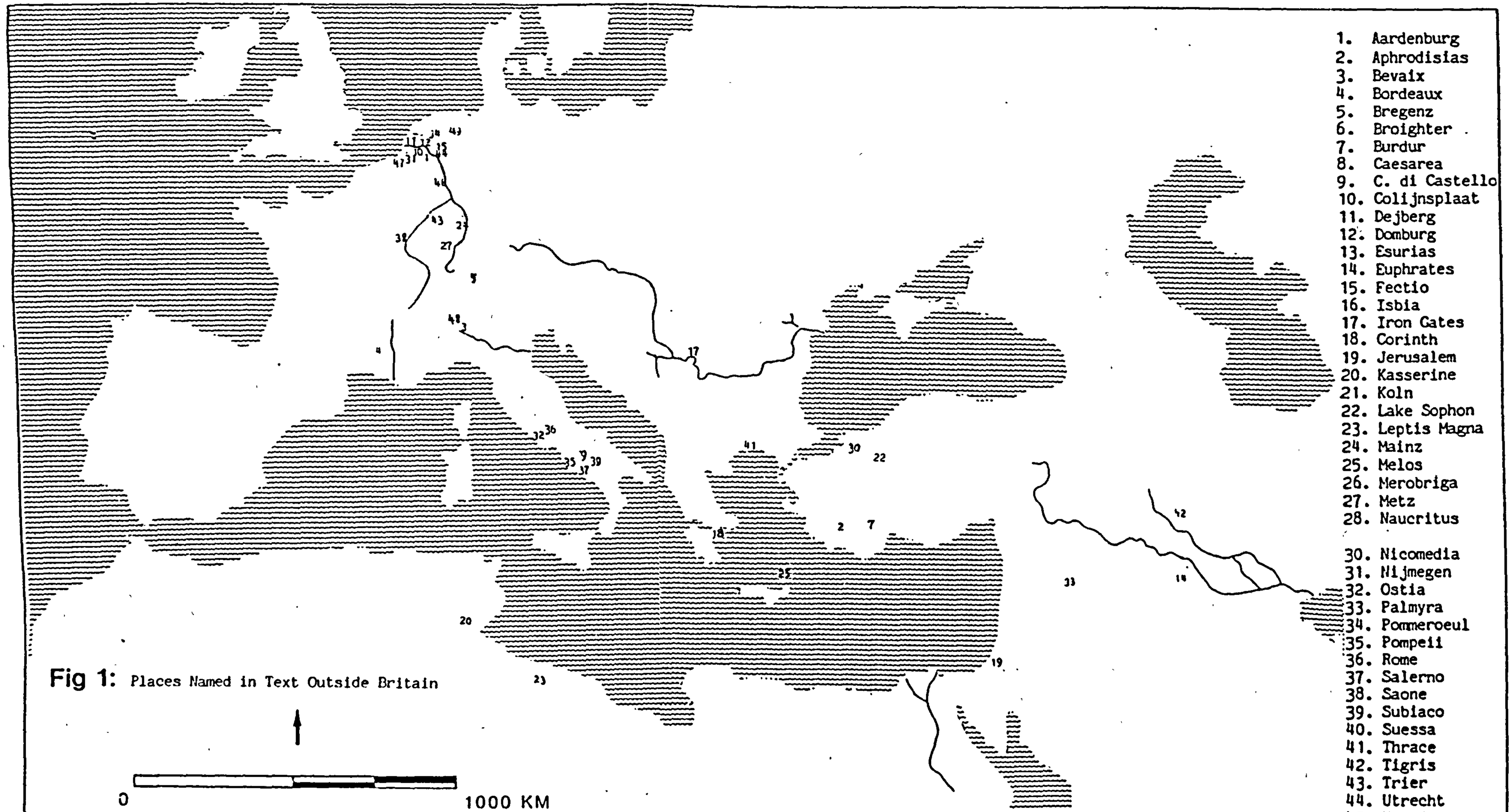


Fig 1: Places Named in Text Outside Britain

CHAPTER ONE

INTRODUCTION

In The Piercebridge Formula: A Dramatic new view of Roman history (1983), Raymond Selkirk argues that river systems were used as transportation media across Roman Britain. This premise does not seem at first to depart from accepted theory:

> "...good land communications were essential for Roman civilization, but waterways were even more important for the transport of any size."
>
> Liversidge, 1968, 401

Indeed, a wealth of evidence attests to river-borne supply across the Empire. As described throughout ancient literature, transportation was carried out whenever large rivers were naturally navigable (discussed in Appendix G). However, what sets the Piercebridge formula apart from traditional theories is the extent to which it is suggested that rivers were exploited in the Roman period, and the method by which they were developed.[1]

According to the Piercebridge formula, rather than to protect a crossing, Romano-British forts were constructed along rivers so that they could be supplied by barges: in North Britain alone, thirty-six forts

---

[1] Henceforth, the word 'formula' will appear in the lower case when referring to the concept of the Piercebridge formula, and in the upper case and underlined when referring to the work The Piercebridge Formula (Selkirk, 1983).

would have been thus supplied (Selkirk, 1983, 101). Certain structures, or components, constructed in river channels or within their banks would have allowed barge passage to forts along rivers which today are in some stretches little more than streams. Heavy gravity dams 10 feet high (3.07m) constructed at right angles to the water course would have raised river water levels high enough to allow continued passage to dams further upriver (Selkirk, 1983, 131, 135). Such static barriers would have been negotiated by lifting devices placed either in the dams themselves, or in canals by-passing the dams. Canals, with the addition of wharves, also might have functioned as harbours near forts, facilitating transfer of goods from barge to land and vice versa.

An aim of this thesis is to test the Piercebridge formula. First, it will be assessed in terms of its theory: that is, the Roman army constructed Piercebridge formula components to facilitate river-borne supply because it was a considerably more efficient supply medium than the road system already in place or under construction. To this end, an assessment will be made of the efficiency of Piercebridge formula river transport vis-á-vis overland transport in the Roman period over a specific survey area, the North-east of England. Second, having assessed its theoretical basis, evidence for the Piercebridge formula will be examined at ten sites across the North-east.

A second aim of this thesis is to advance an alternative to the Piercebridge formula method of supply to the Roman army in the North-east.

Fig 2: The North-east

SITES IN SURVEY

OTHER SITES IN TEXT

ALN

COQUET

WANSBECK

REDE

SOUTH TYNE

TYNE

WEAR

TEES

NORTH SEA

AREA 3

AREA 2

AREA 1

1:500,000

0 10km

1. Low Learchild
2. Brinkburn
3. High Rochester
4. Blakehope
5. Risingham
6. South Shields
7. Wallsend
8. Newcastle
9. Benwell
10. Rudchester
11. Bywell
12. Corbridge
13. Halton Chesters
14. Chesters
15. Carrawbrough
16. Vindolanda
17. Housesteads
18. Great Chesters
19. Ebchester
20. Lanchester
21. Chester-le-Street
22. Binchester
23. Piercebridge
24. Bowes
25. Greta Bridge
26. Carkin Moor

1.1 THE SURVEY AREA: THE NORTH-EAST

Before examining the theory and evidence for the Piercebridge formula, a brief discussion of the survey area is in order. Located in the North-east of England, it is bounded on the east by the North Sea, the south by the River Tees, the west roughly by the line of Dere Street, and the north by the River Aln. The area is further divided into three - Area 1 south of Hadrian's Wall, Area 2 along and immediately south of the Wall, and Area 3 north of the Wall. The following military, geographical, and geo-political considerations recommended the North-east as a survey area to test the Piercebridge formula.

1. According to the Piercebridge formula, the Roman army constructed the various components throughout Britain at the Conquest, and used them throughout the Roman period for fort supply. Therefore, evidence for these components is most likely to be found where the military is most heavily-concentrated. By the 2nd century, most of the army of Britain was stationed in the north. After the army of Conquest under Agricola had advanced through this area to the north of Scotland, where it fought and won the battle of Mons Graupius, trouble on other frontiers forced a retreat. It is generally held that by the beginning of the 2nd century, forts in Scotland had been abandoned and their garrisons transferred to forts constructed on the Stanegate road along the Tyne-Solway corridor. Under Hadrian, this corridor essentially became a limes with the construction of the Wall system just north of the Stanegate road. Although Antoninus Pius advanced the frontier to the Forth-Clyde isthmus

ca AD 142, the line was returned to the Tyne-Solway probably within two or three decades. Apart from a few further interruptions, the main part of the British provincial army was stationed in the north as part of the Hadrianic Wall system until the end of the Romano-British period. The size of this army was considerable: by the mid-2nd century, the British army was the largest provincial army in the Empire.[1] As for the size of the army in the North-east, it has been estimated that at its early 3rd century numerical peak, it may have comprised as many as 17,000 soldiers (see Appendix A).

These soldiers manned a number of forts over different time periods across the three areas of the North-east. In Area 1, 'hinterland forts' at Binchester, Ebchester and Lanchester were constructed along Dere Street from the Flavian period, while forts at Chester-le-Street and Piercebridge were constructed from the 2nd and 3rd centuries, respectively. In Area 2, the Flavian period forts at Red House and Vindolanda were supplemented in the Hadrianic period by numerous Wall forts,[2] while the first fort at South Shields dates from the Antonine period. All of the forts in Areas 1 and 2 ceased functioning militarily by the end of the 4th century. In Area 3, Flavian period forts were constructed at Low Learchild along the Devil's Causeway, and at Blakehope

---

[1] The British army was larger than the sum of the armies of Egypt, Cyrenaica, Proconsular Africa, and the two Mauretanias, while it was almost as large as the sum of both Germanies and Raetia (Daniels, 1991, 48).

[2] Hadrianic Wall forts in Area 2 of this survey area include Wallsend, Newcastle, Benwell, Rudchester, Halton Chesters, Chesters, Carrawburgh, Housesteads, and Great Chesters.

and High Rochester along Dere Street, while Risingham was constructed during the Antonine period. Low Learchild and Blakehope seem to have been abandoned by the beginning of the 2nd century, while High Rochester and Risingham continued in occupation until the 4th century.

2. As for geography, most of these forts are positioned along small rivers which fall steeply from high altitude headwaters to their mouths at the sea. According to the Piercebridge formula, many static barriers would have been necessary along these steeply-gradated rivers to allow barge passage to forts beyond the tidal limits, and the ratio of static barriers per kilometre would have been very high. In addition, the forts of the North-east sometimes lie many kilometres above the tidal limits of their respective rivers, necessitating construction of static barriers as far as 82km (see table 1) along the river systems.

Evidence for these barriers should be more visible along the rivers of the North-east than anywhere else in England. Above their industrial mouths, long reaches of North-eastern rivers flow through valleys which traditionally have been under cultivation, or, as in the last century, under pasture, moors, or woodland. Thus long stretches of river valleys have not suffered the ravages of urban and industrial development common to river valleys in other parts of the country.

3. Finally, this survey area provides a geo-political background to the question of supply to Roman forts. In The Piercebridge Formula, the formula is applied throughout Britain (Selkirk, 1983), with no

distinction drawn between methods of supply to forts in different areas: Piercebridge formula components facilitating the supply to forts in the north of Scotland and outside the Empire are the same as those facilitating supply to forts south of Hadrian's Wall. However, the three areas of this survey area collectively include three geo-politically distinct areas of Roman Britain. Area 1, lying south of the Tyne-Solway corridor, was from the Flavian period within the province, while construction of the Wall system rendered Area 2 a military sphere along the 'frontier' from the Hadrianic period onwards. In contrast, Area 3 remained for most of the Roman period outside the province and Empire. Therefore, when applied to the forts in the three areas of the North-east, the Piercebridge formula system of supply is tested within, along, and outside the provincial and Imperial 'border'.

CHAPTER TWO

THEORY

Ample references in ancient sources attest to the inefficiencies and inadequacies of overland transport. This viewpoint is summed up as follows:

> "The ox was the chief traction animal of antiquity, the mule and the donkey his near rivals... all three are slow and hungry... A state could afford to engage ox-teams for the extraordinary purpose of shifting marble column-drums for temples (and other endeavors)... but individuals could not move bulky merchandise long distances by land as a normal activity, nor could any but the wealthiest and most powerful communities... Towns could not safely outgrow the food production of their own immediate hinterlands unless they had direct access to waterways."
>
> Finley, 1973, 126

Indeed, upon rivers naturally navigable, river transport would have been intrinsically more efficient than overland transport in any age before railways. For example, it has been estimated that in 18th century England a pack-horse could carry at most 2.5cwt [127kg] of coal, while the same horse could pull up to 250 times as much along a navigable river (Porteous, 1977, 9).

However, the rivers of the North-east today are at best navigable only in stretches, and certainly not from their mouths to the many forts listed in the Piercebridge formula. The question, then, is whether river transport would have been so much more efficient than the Roman road

system if the rivers of the North-east were developed with Piercebridge formula components.

2.1 PIERCEBRIDGE FORMULA RIVER TRANSPORT EFFICIENCY

Above all else, the introduction of static barriers upon river regimes sets the Piercebridge formula of river supply apart from traditional theories of transport along naturally navigable rivers. The following section will focus on construction of static barriers, maintenance of the system once developed, and negotiation of static barriers by lifting devices.

2.1.1 Construction of static barriers

Estimating the character of the Piercebridge formula gravity dam is made difficult by the fact that none has hitherto been identified on rivers of the North-east or elsewhere in Britain. However, a reasonable paradigm of a Northern Romano-British river dam might be found at Lanchester in Area 1. Although not strictly a 'river' dam, a Roman period aqueduct dam forced water from two springs into a leat on the dam's south aspect. Excavated in 1938:

> "[The dam measures] 110 yards [99m] long ... roughly faced with freestone boulders ... one course high on the east, two courses high on the west... the foundations consist of a spread of stiff blue clay 1 ft. - 1 ft 6 in. [30-45cm] thick, laid over the dark peaty vegetation of the bed of the original water-course... above [which] was a band of silty yellow clay ... rising at the back to a height of 2 ft. 6 in. [.75m]. The two rear blocks were toothed into the clay, but the inner facing stone, while externally bedded on clay, was otherwise slotted into the clean sand deposit

> forming the upper part of the mound... the barrier was composite... some 18 ft. [5.4m] wide, built of clay with an inner and outer facing of masonry... the height of the dam cannot be less than 15.83 ft. [4.7m] ... and [probably] 20 ft. [6m]."
>
> Steer, 1938, 214-16, 220

This structure's remarkable state of survival attests to its solid construction. As will be demonstrated, the rivers of the North-east would have been inundated by torrential annual floods, and only the strongest structures would have survived. Its great length of 99m is, however, longer than would have been necessary for most of the dams in the North-east. Therefore, a hybrid is sought.

As a river course widens from its headwaters to the sea, the midway point of its course represents the average width of river and minimum length of dam necessary. The midway mark along the longest navigational course in the North-east, from South Shields on the Tyne to High Rochester, via the North Tyne and Rede, is near Chesters fort.[1] As the width of the Roman period river at Chesters was ca 60m (Bidwell and Holbrook, 1989, 1), this figure also might represent the average length of a Roman period river dam in the North-east.

It is estimated in Appendix B that a Roman river dam 60m long, 5.4m wide, 4.7m high, with an inner and outer wall, masonry cover, and clay filling, would have required 5,678 man/days, or 30 man/years to construct.

---

[1] High Rochester lies 102km along the river systems from South Shields, and Chesters 50km.

Table 1: Piercebridge Formula Dam Quantity and Distribution

	Site	OD of River Closest to Site	Tidal Mark OD	No. PF Dams Needed	Distance from Site to Tidal Mark	PF Dams/Km
Area 1						
	Piercebridge	Tees 50	5	12	30	.4
	Binchester	Wear 61	4	19	38	.5
	Lanchester	Browney 120	4	38	41	.92
	Ebchester	Derwent 61	5	19	15 (?)	1.26
	Chester-le-Street	Wear 5	4	None	3	None
Area 2						
	South Shields	Tyne BTM	-	-	-	None
	Wallsend	Tyne BTM	-	-	0	None
	Newcastle	Tyne BTM	-	-	0	None
	Benwell	Tyne BTM	-	-	0	None
	Rudchester	Tyne BTM	-	-	0	None
	Halton Chester	Tyne 30	5	9	16	.56
	Bywell	Tyne 15	5	3.3	8	.41
	Corbridge	Tyne 30	5	9	16	.56
	Chesters	N.Tyne 61	5	19	29	.65
	Carrawburgh	S.Tyne 90	5	29	40	.72
	Vindolanda	S.Tyne 90	5	29	40	.72
	Housesteads	S.Tyne 90	5	29	40	.72
	Aesica	S.Tyne 107	5	35	47	.74
	Haltwhistle Burn	S.Tyne 107	5	35	47	.74
Area 3						
	Risingham	Rede+N.Tyne+Tyne 126	4	41	52	.78
	Blakehope	Rede+N.Tyne+Tyne 168	4	55	64	.85
	High Rochester	Rede+N.Tyne+Tyne 213	4	70	82	.85
	Brinkburn	Coquet 75	4	20	20	1
	Low Learchild	Aln+Coe Burn 75	4	24	32	.75

Key

OD: Ordnance Datum

PF: Piercebridge Formula

N.Tyne: North Tyne

S.Tyne: South Tyne

BTM: Below Tidal Mark

JA/91

Quantity

Mathematical equations can be used to estimate the number and density of dams necessary for the supply of forts according to the Piercebridge formula. On each river in the North-east, the modern tidal limit is used as the lowest point from which dam construction would have commenced, and the OD[1] of the tidal limit is subtracted from the OD of the river below the fort in question. This gives the height of fall 'A'. 'B' represents the lift created by a single dam. According to the Piercebridge formula, each dam would have raised the river's water level 10 ft (3.07m) (Selkirk, 1983), a figure which was used also during the eras of River Improvement (ca 1660-1730) and Canals (ca 1760-) for navigation dams.[2]

Therefore, 'B' equals 3.07m. The dividend of A and B equals the minimum amount of Piercebridge formula dams ('C') necessary to facilitate barge transport from a sea-port upriver to the fort in question. If 'D' represents the distance of the river between tidal mark (TM) and fort, the dividend of 'D' and 'C' equals the number of dams per kilometre ('E') necessary to supply the fort.

---

[1] Ordnance Datum above Mean Sea Level.

[2] For example: "The locks on the Birmingham Canal ... rise 9 or 10 feet" (Chapman, W, 1795c, 11); "The end of this level canal will be 64 feet above the proposed basin at Hexham, which will require seven locks of 9 feet 2 inches fall each." (Whitworth, 1797a, 5); "The locks ... rise 9 or 10 feet" (Sutcliffe, 1795, 13); "...from the summit at Hexham to Stella, 103 foot fall. ... 12 locks will carry us through the whole line to Hexham" (Dodd, 1795, 31).

A (height of fall) equals C (dam quantity)
B (lift of dam)

C (dam quantity) equals E (dams/km)
D (distance between TM and fort)

On Table 1, the route to High Rochester, via the Rivers Tyne, Rede and North Tyne would have required 70 dams, the highest number for a single river route, while the River Derwent to Ebchester would have required the most dams per kilometre, at 1.26. In all, 199 dams would have been necessary across the North-east, and their construction would have required 1,147,832 man/days, or 5,739 man/years. This equates to 199 teams of 30 men working for one year.

Roman period sea levels. In addition, even though a wealth of evidence attests to a rise in sea level during the Roman period to a peak ca AD 400,[1] recent research suggests that the mean sea level of the Roman period was much lower than it is today. Waddelove and Waddelove (1990, 253-266) have devised a formula for estimating Roman period sea levels. The Roman period HAT (Highest Atmospheric Tide) is estimated by a consideration of various archaeological features associated with tidal river systems, such as causeways, roads, floors, quays, riverside walls, stratified artefacts, and bridge remains. The position of these

---

[1] Evidence for this exists at Caerleon: Boon, 1980 and Waddelove and Waddelove, 1990, 260; Uskmouth: Cunliffe, 1966; English Fenland: Churchill, 1970 and Hallam 1970; Formby in Lancashire: Tooley, 1980; Thames estuary: Porter, 1981, 355; Flanders coast: Mariette, 1971 and Porter, 1981, 354.

structures allows an estimation of the maximum Roman period water level and HAT below each requisite structure. This figure is then compared to the modern OD, and the ratio is then subtracted from the modern HAT over modern OD, so that:

$$\frac{\text{Roman HAT}}{\text{Modern OD}} \quad \text{subtract} \quad \frac{\text{Modern HAT}}{\text{Modern OD}}$$

equals the difference in sea levels between Roman and modern periods

Using this equation, sea levels in the Fenlands have risen since the Roman period a maximum 4.22m, at Roman London 4.1m, the Medway Estuary 3.7m, Dover 3.93m, the Scilly Isles 4.73m, Caerleon 3.66m, Chester 3.68m, the Wirral 4.65m, and the Mersey Estuary 4.52m (Waddelove and Waddelove, 1990). On average across Britain, the results suggest a rise of over 3.66m in the sea level since the late 1st century AD (ibid., 266).

If these calculations are correct, tidal marks of rivers in the North-east would have been much lower in the Roman period than they are today: supply boats would not have been able to ply the same distances upriver before running aground, so that, according to the Piercebridge formula, construction of components to facilitate navigation would have commenced further downriver than modern tidal limits. Thus, more rather than less static barriers would have been required, and the figure of 199 represents the minimum number of necessary Piercebridge formula static barriers.

2.1.2 Maintenance of river systems with static barriers

If developed with Piercebridge formula static barriers, the rivers of the North-east would have required much maintenance. An idea of the nature and degree of such maintenance can be gained from consideration of historical parallels.

Lowland England in the 17th-18th centuries

Rivers were 'improved' across Lowland England in the post-Medieval period (ca 1660-1730) by methods very similar to those outlined in The Piercebridge Formula. For example, as set down in a Parliamentary Act, various undertakers[1] of the improvement were authorized:

> "... to clean, scower, open, enlarge, or straighten the said River, or any other streams, brooks, or Water Courses, which do come, or maybe brought to the same; and to make, build up, dig...Banks of the said river, ... for bringing Water into the River... and to make Cuts, Trenches, or Passages for water in, upon, or through the Land... adjoining... and to remove and take away all Trees, and other impediments whatsoever, which may anyways hinder Navigation... and to build... bridges, sluices, Locks, Weirs, Penns for Water, Stanks, Dams, Cranes, Wharfs, Ware-houses... and from Time to Time, to alter, repair, amend the same, and to make any Ways, Passages... for the Carry of Goods... to or from the said River... to turn or alter any Highways.. as may ... hinder Navigation... and make towpaths... make use of Winches, and other engines in convenient Places."
>
> Anon.2, 1713-15, 1-7

---

[1] As well as their heirs and assigns, deputies, agents or officers, workmen and servants (Anon.2, 1713-15).

However, although the development of rivers in the period of Improvement enhanced both transportation and communications across England, such river development was fraught with difficulties:

> "It is certain that in the case of English navigable rivers of any type, much might require to be done, and spent, in order to keep navigation open. With most of them it was a matter of carrying on an unceasing warfare with elemental conditions."
>
> Pratt, 1912, 158

Indeed, apart from many inconveniences, such as serpentine courses which added many kilometres to the length of journeys, flooding and siltation were the main impediments to efficient transport along improved rivers.

Flooding destroyed river banks and the works constructed on them (Pratt, 1912, 156). On the river Trent, traffic was impeded throughout the whole flood season, while on the Severn, flood waters in the river rendered it impossible for the larger vessels to pass under the bridges, so that "a vessel may go up when the water is low, and a freshet may come, and the vessel may not be able to get back again for perhaps many days" (Pratt, 1912, 155). At York, floods sometimes raised the Ouse 5m above summer levels, rendering passage impossible (De Salis, 1904).

The introduction of static barriers rendered improved rivers prone to siltation, so that the river systems would have required much maintenance. In the 17th century:

> "Whereas there hath been for some hundreds of yeares a good navigacion betwixt the burrough of Boston and the river of Trent and through the city of Lincolne... and Yorkshire... at present the said navigacion is much obstructed and in great decay by reason that the river or antient channells of Witham and

> Fossdyke, which run betwixt Boston and Trent are much silted and landed up and thereby not passable with boats and lyters as formerly...
>
> Anon. 3, 1671

Unfortunately, contemporary accounts recording such necessary maintenance during the Improvement are general and anecdotal. However, much recent scholarship has focussed on the general processes of siltation set in motion by the imposition of static barriers into river systems.

Whether equipped with lifting devices 'closing' a river system, such as pound-locks, slip-ways, or haul-overs, or devices 'semi-closing' a system such as 'flash-locks' (discussed below, 2.1.3), static barriers directly affect a river's capability to transport sediment (see Morisawa, 1985, 204; Graf, 1985, 50). As the static water above a dam is unable to hold as much sediment as flowing water, alluvia is deposited in a wide-spread layer of silts and clay across the river bed (Graf, 1985, 52). In a closed system, more than 90 per cent of materials are deposited on the floor of the reservoir and remain there throughout the life of the dam (Brown, 1944; Brune, 1953; Churchill, 1948; Borland, 1971). For example, Gillespie dam, a 10m high concrete spanning arch, was constructed in 1921 to span the highly-charged Gila river 16km north of Gila Bend, Arizona: within two years the reservoir area behind the dam was completely filled with sediment (Graf, 1985, 52).

Such alluvial deposition at the dam site impedes navigation. Indeed, efforts to deepen the water level by dam construction are negated by deposition of silts and clays. Further, such silts and clays produce

seed beds for the growth of riparian vegetation such as willows (Harris, 1966). In addition, the increase in river levels created by such deposition, as well as by the dam itself, inundates terrain never before exposed to aquatic conditions. With the saturation of such material, slopes become unstable, and landslides or even rock falls occur on cliffs of sedimentary rocks (Graf, 1985). Any material thus entering the reservoir will further decrease its depth and navigability. In a pamphlet arguing the merits of building a canal from the Trent to the Mersey (1714?) in order to avoid a river passage, the effects of such structures were described as follows:

> "...in River Navigations the Locks being frequently erected on low Lands the Neighbouring Meadows are thereby often rendered damp and swampy."
>
> Anon.1, 1714(?), 19

Static barriers also increase alluviation rates in rivers sometimes far above the dam site. Although not as dramatic as at the dam site, the reduced velocity of the river nevertheless creates lateral river migration which undermines banks, thus precipitating higher sediment concentrations and eventual deposition along the river bed (Graf, 1985). In addition, the pace of water in fast-flowing, highly-charged tributaries entering the main channel is immediately decreased, so that shoals are formed near the tributaries' mouths.

In total, navigation along 'improved' rivers would have required much maintenance along the entire river course. Maintaining a water depth

sufficient for navigation at the site of a closed dam would have required dredging of silts and clays and the removal of riparian vegetation. On the basis of siltation rates above a dam across a silt-prone river, such as the Gillespie dam across the Gila, dredging would have been necessary at least annually (Graf, 1985). Upriver from both closed or semi-closed dams, shoals at tributary mouths, as well as landslides and rockfalls created by a widened river channel would have to have been cleared.

Such necessary maintenance led eventually to the construction of artificial canals for transportation and supply. Unlike a river and its catchments, which adjust to any alteration in the environment (Morisawa, 1985, 209), a canal regime is more stable, and can be controlled more easily. In a pamphlet expounding the merits of canal over river transport, it is noted that:

> "... the Conveyance upon [canals] is more speedy, and without the Interruptions and Delays, to which the latter are very liable... The Losses, Disappointments and Discredit of the Manufacturers arising from this Cause [that of river transport] are so great, that they frequently choose to send their Goods by Land, at three Times the Expence of Water Carriage, and sometimes even refuse to supply their orders at all, rather than run the Risque of forfeiting their Credit, and submitting to the Deductions that are made on this Account."
>
> Anon.1, 1714(?), 19-20

By the middle of the 18th century, rivers were supplemented with canals in areas of difficult navigation, until a precedent was set with the Duke

of Bridgewater's construction of the first totally artificial waterway.[1]

The North-east in the late 18th century

It is significant that the Tyne and its tributaries did not undergo development in the Age of River Improvement, despite the considerable potential of the Tyne catchment. When considering the advantages of a navigable inland waterway, R Dodd wrote (1795, 4):

> "the immense Lead Trade, the vast quantity of Limestone, Coal, Iron, Iron Ore, Stone, Timber, Hemp, Flax, Slate, Glass, that will employ this Navigation, the ingenuous mind, charmed with national improvement, dwells upon the picture before it with astonishment and delight, and seems to wonder that a scheme so pregnant with the blessing to society should never before have been carried into execution.

In addition, trade from Newcastle to Carlisle in this period was impressive: one hundred ships put into the Tyne in 1796, each of eighty or ninety tons (Whitworth, 1797b, 31). That this cargo was carried overland from Newcastle to Carlisle[2] is particularly remarkable when one considers the state of 18th century northern roads. Travelling through Area 1 to Newcastle in 1724, Defoe described the journey as follows.

---

[1] In the Act permitting its construction, this canal was meant to be navigable at all times, independently of the tides, droughts, and floods, would be 15km shorter than the rivers, and the tariff for the goods carried was not to exceed six shillings per ton (Pratt, 1912).
[2] The rate of overland transportation between Newcastle and Carlisle during this period averaged about 20 miles (32km) per day (Jackman, 1962, 347).

" ... in general [it] is a paved causeway, as narrow as can be conceived, and cut into perpetual holes, some of them two feet deep, measured on the level; a more dreadful road cannot be imagined; and wherever the country is in the least sandy the pavement is discontinued, and the rutts and holes most execrable... Let me persuade all travellers to avoid this terrible country, which must either dislocate their bones with broken pavements or bury them in muddy sand."

Defoe, 1724

As for Area 3, Defoe was even less impressed:

"I must in general advise all who travel on any business but absolute necessity to avoid any journey further north than Newcastle. It is ... devoid of all those improvements and embellishments which the riches and spirit of modern times have occasioned in other parts... Until better management is produced I would advise all travellers to consider this country as sea, and as soon think of driving into the ocean as venturing into such destable roads."

ibid.

The continued use of these roads attests to the formidable obstacles of flooding and siltation which precluded development by water engineers of the rivers of this survey area. Indeed, throughout the ages, great floods have inundated rivers of the North-east. For example, the well-documented Great Flood of 1771 is best remembered as removing every bridge on the Tyne below Corbridge, as well as the bridges at Frosterley, Wolsingham, and Witton along the Wear, and flooded the streets of many towns along the Tees (Jones, Ogilvie, and Wigley, 1984, 73-4). Although not as dramatic as the 1771 torrent, historical records attest to great floods occurring along North-eastern rivers at no more than five year

intervals.[1]

The reasons for the high degree of flooding are two-fold. First, the rivers of the North-east draw upon huge catchments. For example, after the North and South Tyne empty into the Tyne, the combined catchment is 2,175.6km sq (Jones, P D, 1977, 4), rendering the instantaneous discharge at Bywell the second highest recorded in Britain (ibid.). Second, the headwaters of the rivers and their tributaries are located high in the hills of the Pennines and Cheviots, and must fall rapidly before discharging into the sea.

That flooding was a major concern to river improvement is attested by an 18th century hydraulic engineer:

> "... a Navigation of the Tyne ... above its tide-way would be ill-suited to what ought to be the scale of the rest of your Navigation: - that it would be expensive from the great width of the River and nature of its bottom: - that it would be liable to great interruption from floods, and consequently defeat all ideas of regular communication: - that, from the impetuosity of its torrent, which brings down not only gravel, but even stones, shoals would, after great floods, be frequently thrown up, where navigable water was before."
>
> Chapman, W, 1795a, 1

In addition to flooding, siltation has also been a problem endemic to North-eastern river systems until quite recently. Indeed, historical accounts attest to the problems encountered when static barriers were

---

[1] For a collection of such accounts, see Jones, Ogilvie, and Wigley, 1984).

imposed on the River Tyne. In the 14th century, individual fisheries began defying Newcastle's claim to be the sole market by establishing independent fish quays. The Newcastle Burgesses complained that not only did these fish traps sunk across the channel's width almost block the Tyne's shipping, but the collection of silt around their timbers blocked the shipping lanes (Fraser, 1961, 144).

As for the late 18th century, static barriers in the form of 'spouts' were constructed on the banks of the Tyne, which, pivoting from a base on the bank and swung out over the river, enabled ocean-going ships downstream from the bridge at Newcastle to be loaded directly from the bank. In 1822, Keelmen struck not only because the implementation of these spouts threatened their livelihood,[1] but because the stays of the spouts driven into the river created serious accumulations of mud and sand which impeded navigation (Mitcalfe, 1937, 12). After the strike, the Keelmen brought a Wallsend colliery to court over the issue at the York Assizes in August, 1824. Although the courts ruled in favour of the defendant in this case, as well as a similar case in Carlisle in 1828, the problems of siltation created by these static barriers in the Tyne were duly acknowledged.

---

[1] Keelmen carried coal in keel-boats from collieries along the Tyne's bank to ships further downriver. A shipping list contemporary with the strike attests to over 1000 ships registered in the port of Newcastle, nearly all of which were employed in the coal trade (Mitcalfe, 1937, 14). Keelmen are described in more detail in Appendix L-3.

"We find that part of the navigable Channel of the river Tyne opposite to Wallsend has been straightened, narrowed, lessened, and obstructed by the gears described in the indictment;"

from Mitcalfe, 1937, 15

Various canal proposals in the late 18th century underline the unviability of developing North-eastern rivers. Numerous engineers[1] proposed cutting a canal either on the south or north bank of the Tyne and across to the west coast to connect the east and west seas. One proposal (Chapman, W, 1795a; b) saw a system running from Haydon bridge to the upper parts of Newcastle, from which goods would be conveyed to the river either by a kind of stair-case of locks, or in wagons on an inclined plane. A south bank canal was meant to leave the river about Stella, and after 12 (Sutcliffe, 1795) or 24 locks (Dodd, 1795), eventually to conclude at Hexham. From Hexham, further canals would be cut to Carlisle and the west coast. In total, these canals would have included construction of numerous aqueducts, tunnels, embankments, inclined planes, and multiple locks. Although the canals were never constructed,[2] the thought invested as well as the huge costs involved in such proposed projects reveal the unwillingness and futility of attempting to 'improve' the navigability of the Tyne's channel.

---

[1] These include Dodd, R, 1795; Chapman, W, 1795a, b, c; Jessop and Chapman, 1795; Sutcliffe, 1795; Thompson, J, 1795.
[2] Although subscriptions for defraying the expense of the north line were filled, and application for an Act of Parliament was made in 1797, it met with so strong an opposition from the landowners, that it was thought proper to withdraw it (Bailey, J and Culley, G, 1805).

As for Area 1, if a south bank canal along the Tyne was to be chosen:

> "Newcastle... must become the Emporium of the North of England; as a Canal may easily run from the higher part of Gateshead, by way of Chester-le-Street, to Durham; and, ... much higher up the Vale of the Wear towards Bishop Auckland, so as to draw off the heavy produce of that country, and return the foreign imports necessary for its consumption."
> "...the capability of a level branch [from the south canal] up the Derwent Vale ... would convey lime up that country."
>
> Chapman, W, 1795a, 13; 1795b, 12

These proposed canals suggest the unfeasibility of developing the Derwent and Wear for navigation.

As for Area 3, it was proposed in 1795 (Thompson, J, 1795, 20) that a canal be constructed on the north bank of the Tyne following the Vale of Pont, so that a corollary branch might be taken into Northumberland, crossing the Blyth, Wansbeck, Coquet, Aln, to the Tweed, thus opening up the potential of this area. Thus transportation across Area 3 was thought to have been better served by an artificial canal than by an improved river.

The North-east in the Roman period

It is now to consider whether the forces of siltation and flooding, which created major problems of maintenance upon the improved rivers of Lowland England in the 17-18th centuries, and which precluded development of North-eastern rivers in the 18th century, would have been significant forces in the North-east during the Roman period.

Siltation

1. It seems that the Roman period saw dramatic increases in alluviation rates along river systems of Roman Britain (outside the North-east) and the Mediterranean basin (see Appendix C). Although this evidence cannot be directly applied to the North-east, it seems that the same processes which led to the increase in alluviation rates across the Empire were also taking place in the North-east in the Roman period. Specifically, much evidence suggests significant increases in deforestation and cultivation just prior to and during the Roman period across the North-east.

Both processes lead to a decrease in the density of ground vegetation cover, which decreases transpiration, interception, and infiltration in the topsoil, so that it is made vulnerable to colluviation, or erosion through rainfall, wind, and gravity (Knighton, 1984, 194). Such sediments are collected in colluvial banks,[1] as well as sheet, rill, gully and bed formations, and afterwards are released by rainfall into the river systems.

Eight out of a total of nine pollen diagrams produced for a region corresponding roughly to the North-east have indicated that during most

---

[1] These depositional banks form where a gently sloping hilltop or plateau surface dips abruptly to a valley or scarp face, near or on lynchets, alluvial edge terraces, and dry valley fills (Bell, 1981, 75, 79).

of the Iron Age the landscape was well-forested, as it had been during both the Bronze Age and Neolithic (Turner, 1979, 286). In Area 1 (southern County Durham and Weardale), clearance of mainly hazel, oak, and alder (Branigan, 1984, 27) intensified in the 1st century BC, and progressed into the 1st century AD (Haselgrove, 1984, 12). In Areas 2 and 3, pollen diagrams at Fellend Moss near Hadrian's Wall, Steng Moss near Elsdon in mid-Northumberland, and Broad Moss, 390m above the sea in the north Cheviots, provide evidence for deforestation (Davies and Turner, 1979) from the Late Iron Age through the Roman period, and continuing into the 5th to 7th centuries (Turner, 1979, 288; Gates, 1981, 35). Between BC 100 and AD 200, a large proportion of wooded areas in eight of the nine areas recorded (Turner, 1979, 286) across all three areas of the North-east were being replaced by pastoral and arable species.

The full impact of Late Iron Age deforestation upon river regimes would have been felt in the Roman period. Although colluvia reflect localized erosion, alluvia reflect much larger scale changes affecting a significant portion of the catchment. Even if the original clearance of some areas took place at a comparatively early date, it may have been much later, with the creation of continuous expanses of arable land, that sediment was deposited in rivers in considerable quantities (Bell, 1981,88-9).

As for cultivation, although traditionally thought bereft of many good cereal producing areas (Wheeler, 1954, 27; Piggott, 1958; Rivet, 1969a,

189), recent evidence suggests extensive cultivation in the North-east in the Late Iron Age and Roman periods. Briefly (discussed fully in Appendix D), not only does a large body of evidence suggest extensive agricultural land-use across all three areas, but the position of field systems and pollen recovery suggests strongly that marginal Highland areas were being cultivated in the Late Iron Age and Roman periods. As these field systems have been recovered sometimes at far higher altitudes than those of other periods, it is reasonable to conclude that the extent of Late Iron Age and Romano-British cultivation was at least as great, if not greater than at any subsequent period.

High levels of sediment in colluvial run-off in the Roman period, consequent upon extensive clearance and cultivation, would have emptied into rivers which, as a result of drier periods (discussed below) would have had low water volume. Further, the higher the ratio of sediment quantity to water volume, the higher the rates of alluviation. Therefore, increased sediment and decreased water volume would have created a situation of high alluviation rates in North-eastern river systems during the Roman period.

2. An idea of the sediment concentration within a river system can be gained also by consideration of a river's width. Indeed, high concentrations of alluvia slow a river's pace: the slower the pace, the greater the deposition along the river bed, while the gradual decrease in depth results in a lateral movement of the river's course. In contrast to the North-eastern rivers of today which are fast, narrow and

deeply-incised due to well-vegetated catchments and consequently low rates of colluvial erosion and alluviation (Ferguson, 1981, 125, 122), evidence suggests that these rivers were much wider in the Roman period.

Today the river North Tyne at Chesters fort is 50m wide, while in the Roman period, the first bridge was built to accommodate a river at the most 61m wide, and the second a river 58m wide (Bidwell and Holbrook, 1989, 1). At Chesters, then, the bridge spanned a river possibly 8m wider than today.

Fed by the North Tyne as well as the South Tyne, the Tyne at Corbridge may have been much wider in the Roman period. The extant remains of the bridge suggest a structure set askew to the modern river course, and it is generally held that the river has changed course in this area (discussed below, 4.3.2). The highest figure for the width of the Roman period river is that of Bourne (1967) who bases his figures on the existence of a northern bridge abutment (see figure 28). By these calculations, the Roman period river would have been 132.5m wide, at least during high spates, more than double its present 65m width.

It is likely that these rivers were wider because of high alluviation rates rather than high Roman period water volumes within the river systems. Indeed, from BC 150, with exceptions in AD 250-263, weather across Northern Europe became generally milder, less stormy, and most importantly, drier (Lamb, 1981), with a probable world-wide peak in the 3rd and 4th centuries to about the year 400, after which a colder climate

prevailed (Lamb, 1981, 53-65).[1] Although droughts are not recorded in the British Isles and Central Europe, reports of flooding decline dramatically after AD 270. In addition, it seems likely that the condition of riverside land and marshes, as at the early Saxon village of West Stow in Suffolk, improved over the following 130 years, becoming wetter again in the 5th and 6th centuries, particularly after about 580 (Lamb, 1981).

3. Finally, evidence suggests that soon after the second Roman period bridge at Piercebridge had been constructed, silting began at its southern aspect (Scott, 1982, 77; disussed below, 3.1.2). This process continued, so that by the late 3rd-4th centuries, the water channels between at least the first three piers had completely silted-up (Bidwell and Holbrook, 1989, 112).

Flooding

High rates of cultivation and deforestation in the North-east during the pre-Roman and Roman period would have aggravated an already flood-prone system. Unrestricted by vegetation, winter rains would have washed sediment from fields throughout the catchment, including those of higher altitudes, and inundated the rivers of the North-east.

---

[1] Evidence for this world-wide dry period is found most strikingly at the land-locked Caspian Sea, the Roman period level of which is 4m below the modern level (Klige, 1980).

In total, the problems of river maintenance created by chronic flooding and siltation in Lowland England during the Age of River Improvement, and which precluded the development of the rivers of the North-east during the same period, would have been equally as formidable, if not more so, in the North-east during the Roman period.

2.1.3 Negotiation of Static Barriers: Lifting Devices

Pound-locks

The pound-lock is the favoured lifting device in The Piercebridge Formula (Selkirk, 1983, 84). Described above as a 'closed' system, a pound-lock, comprising two gates close together, transfers a vessel in a static position from one level to another. If proceeding upstream, the vessel is pulled into the area between two gates. After the downstream gate is closed, the upstream gate is opened slightly to allow water to fill the area between the gates. After the upstream water level is equalled in the area between the gates, the upstream gate is opened. The system, reversed moving downstream, has the advantage of being safe, and of conserving water and therefore time: it is not necessary to wait for the level of the river to rise after it has been discharged. Pound-locks are incorporated either within a dam itself, or within a 'by-pass canal' skirting the dam.

However, problems exist when one considers the use of pound-locks on North-eastern rivers during the Roman period. First, it is far from

certain whether pound-lock technology was known during the Roman period across the Empire. Some argue[1] that evidence across the Empire suggests that certain canals would have been impossible to negotiate without the use of pound-locks. However, each of these arguments are refuted in Appendix E, and it seems that no literary or archaeological evidence attests to, or even strongly suggests, the use of pound-locks in the Roman period.

On the other hand, even if pound-locks were used in the Roman period, construction of so many facilities would have created problems. As canals by-passing dams sometimes contained two pound-locks, such as at Piercebridge (below, 3.1.1), perhaps many more than 199 pound-locks would have been necessary. In addition, construction of pound-locks can be very complex. An 18th century proposal for a canal along the south bank of the Tyne noted that:

> "... not owing to any imposition or mismanagement, or from falling with an obstinate bed of stone to sink the lock pit in, but merely from torrents of water bursting from springs beneath, with the necessity of building nearly the whole on piles, added to the enormous expence of pumping day and night till the work was brought above the level of the springs..."
>
> Dodd, R, 1795, 43

Once constructed, pound-locks would have required much maintenance:

> "Many are the inconveniences attending locks, when numerous and close to each other; any one of them in disorder, stops nearly the use of the whole; if by accident, therefore, the upper one blows up, there would be great danger, from so long a level of water running off, of destroying those beneath."
>
> ibid., 15

---

[1] Selkirk, 1983; Moore, 1954; Allen, 1933; Smith, N A F, 1978).

In addition, effectively 'closing' the system, pound-locks would have been very vulnerable to flood waters. Unable to pass through the static barriers, the considerable force of North-eastern flood waters would have placed immense pressure and strain upon dam and lock, making regular maintenance necessary.

Finally, as discussed in detail above (2.1.2), the pound-lock closed system would have created additional problems of maintenance over the whole river course. Shoals and bars, landslides, the growth of vegetation, collection of debris, and a host of problems consequent upon a closed system led to the abandonment of improved rivers in the post-Medieval period. As these conditions would have been aggravated by degrees of flooding and siltation perhaps even more considerable in the Roman period, rivers closed by pound-locks in this survey area would have required even more maintenance in the Roman period than in the Age of Improvement.

Therefore, even if pound-lock technology was known in the Roman period, the rivers of the North-east would have been unsuitable for their employment. Construction and maintenance of at least 199 pound-locks would have rendered the system wholly inadequate.

Flash-locks

The second and less preferable system in The Piercebridge Formula is the flash-lock, essentially a 'semi-closed' system. The flash-lock consists of a guillotine gate or set of horizontal boards spanning a canal or gap in a dam. After the gate is raised, water flows from the higher into the lower water level until a balance is reached. The barge is then moved either up or downriver, and the gate is again closed. If moving upriver, bargemen must wait for the level of the water to increase before proceeding.

Unlike the pound-lock, some evidence exists for the flash-lock in the ancient world. As discussed in Appendix E-2.2, they seem to be described in Pliny the Younger's description to Trajan of a method to prevent the draining of a lake in Bithynia when connected by a canal to a river emptying into the sea (Tra 10.61.4-5); a flash-lock seems the more reasonable device regulating the flow of water from a canal connecting the Red Sea and Nile (Strabo Geog 17.1.25); finally, when describing the upper reaches of the Tiber, Pliny the Elder seems to be describing flash-locks (HN 3.53).

However, a flash-lock is inherently inefficient. First, although a flash-lock disperses sediment through the lock in the 'flash', as discussed, much siltation would have occurred up and downriver from the dam, so that regular maintenance of the system would have been necessary.

Second, negotiating flash-locks can be dangerous. Barges are pulled through not only the fast-flowing flash, but through shallow waters, and during the short period of 'flashing' capsizing is common (Willan, 1964). Furthermore, the situation may induce bargemen to attempt risky passages through locks before a balance has been reached (Skempton, 1953). Third, in order to avoid capsizing and spillage, 17th century bargemen sometimes avoided the passage altogether by unloading their cargo before the lock, shooting the flash with an empty boat, and re-loading beyond the lock.[1]

Finally, and most importantly, negotiating flash-locks requires very much time. Pliny's passage demonstrates the amount of time wasted waiting for the Tiber to replenish itself after the flashing period:

> "At first [the Tiber] is narrow, only navigable when collected in ponds and then discharged after an intake of nine days each, unless assisted by showers or rain."
>
> Pliny the Elder HN 3.53

Dissatisfaction with the long periods of time involved in transport along a river equipped with flash-locks is well-recorded for the period of River Improvement. Once having pulled barges through flash-locks, the replenishment of water above the dam sufficient enough to allow further navigation upriver could take anywhere from two hours, to a month or six weeks on the Thames (Yarranton, 1677-81, 188; Willan, 1964, 88). The 17th century description of flash-locks as a "baneful practice" (Jackman, 1962, 431) indeed seems appropriate.

---

[1] To facilitate passage through locks, weirs and shoal-waters on the Thames, cargo was unloaded into 'lightening-boats' (Willan, 1964, 87).

In addition, the rivers of the North-east are small to medium size, and the volume of water input from tributaries, at least in the summer months, is correspondingly modest. Potentially less water volume (discussed above) would have rendered Roman period rivers even smaller. In addition, less water volume combined with alluvial deposition on a system replete with static barriers would have resulted in the formation of bars along the river bed, which would have hindered barge passage. Therefore, once the lock was opened and the flash allowed to disperse downstream, replenishment of the river's water to levels above the dam sufficient for navigation would have taken considerable time.

Estimating the time involved in negotiating flash-locks on the basis of historical accounts is difficult: time spent at a flash-lock in the Age of River Improvement depended entirely on the specific lock and river. However, the absolute minimum time quoted for negotiating a flash-lock is two hours (Yarranton, 1677-81, 188; Willan, 1964, 88). Using this minimum figure, and projected over an eight hour day,[1] a bargemen's journey to High Rochester from Stella on the Tyne would have taken eighteen days.

---

[1] The designation of eight hours for a working day is based on the assumption that the often risky passages through flash-locks would have been undertaken only during daylight hours. Although working days could have been as long as ten to twelve hours in the summer months in the North-east, at the winter solstice the number of full daylight hours during which barges could have been transported in the North-east may not have exceeded six hours per day, so that eight hours per day represents a rough yearly average.

Other systems

Two other systems could have been employed in the Roman period: slip-ways and haul-over devices. Slip-ways, essentially inclined planes sometimes with rollers, are used to negotiate small weirs across England today. Alternatively, haul-over systems such as that used on the Isthmus of Corinth in the ancient period may have been used. The Isthmian diolkos was a paved causeway with grooves along which vessels were carted in wheeled cradles. In addition to ancient descriptions (Pliny the Elder, HN. 4.4.10; Polybius Hist 4.19.7; 5.101.4), the diolkos has been attested archaeologically as 3.5-5m wide with a 'gauge' of 1.5m (Verdelis, 1957).

However, both devices would have 'closed' the river regimes, so that the inefficiences inherent and maintenance necessary to rivers closed by pound-locks would have been endemic also to rivers closed with slip-way and haul-over systems in the North-east during the Roman period.

2.1.4 Discussion

Construction of Piercebridge formula dams in the North-east would have required much effort. The existence of extensive highland areas within the North-east, such as the Cheviots in Area 3, the Pennines in Area 2 and 1, and the North Yorkshire Moors and Cleveland Hills in Area 1, means that its rivers fall from high altitudes, often very quickly before discharging into the sea. Therefore, in order to maintain a water level

sufficient to allow barge passage, a minimum 199 dams would have been necessary, each requiring 30 man/years in construction.

Once constructed, these dams would have necessitated regular maintenance of the entire river system. Indeed, such necessary maintenance forced the eventual abandonment of navigation along Lowland rivers 'improved' with static barriers throughout 17th-18th century England. The forces of flooding and siltation, which played havoc with such improved rivers, were deemed even more severe in the North-east during the same period. Indeed, despite the great potential of the hinterland of the North-east, river engineers passed over this area during the period of River Improvement. Similarly, much evidence suggests that Roman period rivers in the North-east also would have been cursed with the processes of flooding and siltation, perhaps even to a greater extent. High rates of alluviation due to clearance and cultivation, as well as low river levels due to the climate would have silted up the dams, created flood conditions thus eroding banks and damaging static barriers, and formed silt shoals and bars. Maintenance of such a system, both closed and semi-closed, would have been very considerable.

Furthermore, it does not appear that an efficient lifting device was known in the Roman period. Even if knowledge of the pound-lock was at hand (for which there is no evidence in the archaeological or literary record), construction and maintenance of such complex devices can be difficult and costly, and over 199 would have been required. As for the

semi-closed flash-lock, in addition to its potential dangers, the tremendous wastage of water, combined with the already scarce amounts of water in the systems in the Roman period, would have rendered negotiation of a flash-lock painfully slow. In short, lifting devices either fully or semi-closed would have greatly impaired the potential efficiency of the Piercebridge formula.

2.2 OVERLAND TRANSPORT EFFICIENCY

It is argued in The Piercebridge Formula that Roman period forts would have been supplied overland by oxen capable of covering only short distances in a day, with very little cargo, at a great cost, over roads intended for other purposes. This model acts as a foil to the relatively greater efficiency of river transport:

> "I now knew why the steep Roman road gradients did not bother the plaustrum or clabularia, the Roman heavy ox-wagons; they did not use them! The heavy goods all came by water, and the heavy wagons were merely used between the wharves and the forts and in the local area... No longer did I picture [roads] crammed with slow supply wagons; I now saw them as direct communication lines for fast moving cavalry, infantry and dispatch riders. Gradients would not bother infantry and cavalry could dismount for the ascents if necessary."
>
> Selkirk, 1983, 73

The four main ideas contributing to this theory of overland transport will now be examined in the following sequence: the distances as well as loads possible, the cost of overland transport, and the character of Roman roads.

2.2.1 Distance

Arguments supporting the Piercebridge formula

That oxen, the traction used for the draught of heavy loads, could cover only 6 miles (ca 10km) per day (Selkirk, 1983, 59), is suggested by ancient literary sources. In the Early Republic (BC 234-149), Cato the Elder (de Agric. 20.3.3) transported an oil mill from Suessa 40km to his home in Venafrum. The entire journey took six days at 6.4km per day (Yeo, 1946). By 301, Diocletian's Edict on Prices (1.1)[1] stated that a 62km trip would take 6 days.

Arguments Refuting the Piercebridge formula

However, it seems that oxen pulling carts could have covered far greater distances in one day across the North-east than argued in The Piercebridge Formula.

The passages from Cato refer to transport across the foothills of the western Appenines, in the shadows of Mount Vesuvius. However, while often hilly, the North-east cannot be described as mountainous. As for Diocletian's Edict, the transport distances apply to the area from which the Edict was most likely written - Nicomedia (Duncan-Jones, 1974, 367).

---

[1] This work listed transport costs based on a product's original price, weight, distance transported, and time involved in transport.

That transportation was difficult in this area is attested by Pliny the Younger, who, as Governor of Bithynia, proposed to Trajan in AD 112 (Tra, 10.41-62) a canal which would have linked Lake Sophon, 30km south-east of Nicomedia, to a navigable river emptying into the Propontis (see Appendix E-1), thus replacing overland transport through the mountains with comparatively more efficient water transport.

In addition, evidence from the spacing of mansiones, or inns, suggests that these figures represent minimum, rather than average estimates of ancient ox-cart transportation across the Empire. As described in the Theodosian Codex, these inns provided food and accommodation for travellers and officials,[1] and it is assumed that the interval between two mansiones would be covered in one day: indeed, officials would endeavor to find accommodation for the evening, as well as feed and rest the oxen (Tengstrom, 1974; Chevalier, 1976, 185). The Bordeaux Itinerary (Cuntz, 1929), a pilgrim's journey from Burdigala (Bordeaux) to Jerusalem and back in AD 333, records stations occurring at intervals between 16-45 Roman miles, or 25.6-72km (Tengstrom, 1974; Jones, A H M, 1973, 833, 1344-47). Furthermore, Vegetius (ERM 1.9) states that the distances between mansiones corresponds to an average one day's legionary marching stage of 30-36km (Chevalier, 1976, 186).

---

[1] These included couriers of the cursus publicus, provincial governors, judges, imperial bodyguards, members of the secret service and private persons summoned by the Emperor (Codex. 6.29.2; 7.1.9; 8.4.7; 8.5; 8.10.2; 11.1.2; 12.1.21).

In addition, on the basis of figures derived from late Imperial transport, A H M Jones argues (1973, 842) that oxen could travel at the pace of about 2 miles (Imperial) per hour (3.2km per hour). This figure is precisely that recorded for ox-cart transport in modern day South Africa: 2 miles per hour (3.2km per hour) (Green, 1973). As for the duration over which an ox-team can be driven, South African oxen are worked in two five hour shifts in one day (ibid.). However, as discussed above (2.1.3), the average amount of daylight in one day through which oxen could have been driven in the North-east may have been only eight hours. Therefore, at 2 miles per hour (3.2km per hour), an ox team would have been able to cover 16 miles, or 26km in one day over the Roman roads of the North-east. This figure is 2.6 times greater than that which has been argued in The Piercebridge Formula.

This figure also conforms with the spacing of forts along the Stanegate road. In its original form, the Stanegate was lined with four forts constructed at uniform intervals of about 23km (Birley, E B, 1961). As the Stanegate was constructed and used as a communication/transportation route (discussed below, 6.2.1), and because garrisons in the forts constructed along its length functioned to protect this route, it is logical that the spacing of the original forts would not have exceeded the minimum distance possible in one day for the movement of ox-carts, if the convoys were to be protected within fort defences during the night. Therefore, the distance of 23km between the original Stanegate forts represents the absolute minimum distance which oxen could be driven in one day in the North-east during the Roman period, and 25k the overall average.

Pack Animals. Although pack animal transportation is mentioned briefly in The Piercebridge Formula (Selkirk, 1983, 58), it is not considered with respect to long distance fort supply. However, many ancient references record transportation of certain supplies (discussed below) by mules and asses over long distances. Mules would have been able to transport cargo much further than oxen pulling carts. Indeed, mules have tremendous stamina, and can easily cover 80km in one day (Leighton, 1972, 172).

Horses may have been used as draught animals to a certain extent. Lefebvre des Noettes' argument (1931) that ancient harnesses prevented horses from exerting maximum thrusting power (about one third that of modern animals, Burford, 1960, 1-18) has been refuted by replications of ancient harnesses depicted on reliefs, which prove that horses' windpipes would not have been constricted (Greene, 1986; Spruytte, 1983, 101-7; Raepsaet, 1979). However, the scarcity of evidence attesting to horses as draught animals, compared to the overwhelming evidence attesting to the use of oxen, mules and asses, suggests against the use of horses as draught animals on anything but a limited scale.

2.2.2 Load

Arguments supporting the Piercebridge formula

It is argued that oxen could pull a cart weighing only 1000 pounds (454kg), and that it would require twelve carts of cargo to equal the carrying-capacity of one river barge, at 11,750 pounds (5,340kg) (Selkirk, 1983, 83).

Indeed, the Edict lays down a maximum wagon load weight of 545kg. By the time of Theodosius (438), 681kg was the limit given to a post-wagon of the cursus publicus (Codex 8.5.8). Therefore, ancient sources suggest that even if oxen were able to pull more, they were not permitted.

It is argued further (Selkirk, 1983, 60) that carrying fodder would have decreased the amount of supplies transported: an eight oxen team would have required 236kg/day of fodder in the summer, and a ten oxen team 254.5kg/day in winter.

> "If the fodder was carried on the wagon, the ten oxen team would need 1,120 lb [509kg] for a two day journey, but the total cargo of the wagon was only 1,000 lb [454kg]. The distance travelled would have been only 12 miles [ca 20km], so in every 12 miles [ca 20km] the ox team would need more weight in fodder than the total cargo. If the oxen were allowed to graze, this would cut the distance travelled each day to just 2 or 3 miles [ca 3.3km or 5km].
>
> Selkirk, 1983, 60

Arguments Refuting the Piercebridge formula

As will be discussed (6.2.3), some very heavy supplies such as stone and metals probably would have been transported by land over short distances. It seems that the estimates for ox transport produced in The Piercebridge Formula are rather low, and that in fact heavier loads could have been transported overland across the North-east.

Estimates of ancient transport costs are in part deduced from the shipment of Cato's oil mill. However, it has never been determined how many carts were used in this undertaking. If oxen were pulling just one cart, the contents would have weighed 1590kg (Burford, 1960).

Again, the Empire-wide stipulation of maximum weights for the cursus publicus in the Codex and Edict may have been intended to protect roads in the more mountainous regions of the Empire (Greene, 1986), and the load-carrying capacity of oxen along roads in this survey area may have greatly exceeded that of oxen in the Mediterranean basin.

That the codes were meant to protect the roads and animals, rather than represent actual maximum possible loads, is suggested by a passage in Plutarch (see Burford, 1960). Lycurgus (Plutarch Lives 9.1) is said to have devalued the iron currency to such an extent that one yoke of oxen was required to move ten minae worth of goods. According to the Pheidonian standard - an archaic ratio of iron to silver (Seltman, 1953, 37) - ten minae of iron equal 1500kg, or three times the load of

Diocletian's Edict. The mountains surrounding Lycurgus' home in the Plain of Laconia are far steeper and higher in elevation than the hills of this survey area.

In addition, Burford (1960, 187) argues that carts used in building the temple at Epidaurus had a capacity of 1100kg. Again, the mountains throughout the Peloponnese are much higher than the hills of the North-east. Therefore, the more conservative estimate of 1100kg will be used as the paradigm for overland transport in the North-east. Rather than twelve (Selkirk, 1983), only five carts would have been necessary to equal the load carrying capacity of the Piercebridge formula river barge (5,340kg).

As calculated below (Appendix H), a fort of 480 strong soldiers would have required 432kg/day of grain, or 157,680kg/year. This would have required the transportation of less than half the capacity of an ox-cart per day, or 143 ox-carts per year.

Small Shipments. For supplies transported over longer distances such as grain, a system may have existed whereby supplies were kept in 'holding depots' throughout the North-east, making large shipments unnecessary. Writes Gentry (1976, 27):

"There may well have been forts which held reserve supplies to pass on to frontier posts as the need arose, so that a system may have acted as a chain of supply, perhaps with reserves at strategic points. It may have become necessary to reinforce certain areas thus placing increased demand on the supplies of the locality. In this situation it seems impractical to imagine the unit needing to wait for and depend upon supplies from a

> distant depot. Its seems more feasible that a reciprocal operation would be in force, whereby reserve stores of grain could be passed on from holding depots, which themselves could be replenished subsequently more readily from a main supply base."

Evidence, albeit slight, suggests the existence of such 'holding depots'. At Binchester in Area 1, seven buildings lining the south side of Dere Street, starting 60m east of the fort, perhaps represent storage facilities.[1] Furthermore, substantial works compounds (discussed below, 6.2.1) as well as the position of the fort near the junction of Dere Street and a cross-road to the east leading to the fort at Chester-le-Street, also suggest a centre of some sort, and perhaps a 'holding depot'.

Further evidence may come from the fort at Benwell in Area 2. The size of a granary discovered there has been calculated as 613.7m sq (Gentry, 1976, 44; see figure 76), which is much larger than average. If this is correct[2] the granary area would have occupied 3.3 per cent of the total internal area (1.84 ha), far outstripping the 1.5 per cent at Housesteads, and .9 per cent at Chesters (ibid., 30). This suggests that Benwell, for a certain period the easternmost Wall fort (discussed below,

---

[1] Hooppell describes these buildings as large and substantial, each with its own four walls, with ornamental doorways, possibly with columns in the earlier phases (1891, 10, and his plate 2).

[2] The precise length of the building cannot be ascertained with complete confidence because the praetentura and the via principalis lay under a reservoir, and it is possible that the excavators overestimated the length of the granary, thus inflating the total floor area available for storage (Gentry, 1976, 44). Nevertheless, the extant evidence suggests a very large granary: 43.28x6.86m (eastern part), and 7.32m west (ibid., 59).

6.3), may have held grain for forts on the eastern end of the Wall.

Also in Area 2, the sites at Red House/Corbridge at the junction of Dere Street and the Stanegate may have served throughout the Roman period as 'holding depots' in the centre of a 'hub', serving forts along the road system (discussed below, 6.2.1). The site at Red House, constructed under Agricola and demolished before the 1st century AD, consisted of a huge military enclosure perhaps 8 ha in area containing a double legionary barrack, a fabrica, and a row of 13 open-ended buildings argued to be stores or worksheds (Daniels, 1978, 100-101). These buildings, together with the large area of the site, and a substantial body of men important enough to have required a bath-house of considerable size suggests that this site served as a depot (ibid., 101), perhaps holding supplies destined for other forts.

As for the sites at Corbridge, as discussed below (6.2.1), evidence within the fort and civilian settlement of works compounds and numerous phases of large granaries suggests a 'holding depot'. The largest granaries, rebuilt in the Severan period (RIB 1143) and covering 480m sq in area, represent 2.43 per cent of the total internal area of the fort, at 18,500m sq (Gentry, 1976, 71-75; discussed below, 6.2.1).

Although given up before construction of the Wall forts, Haltwhistle Burn may have held supplies for the Stanegate forts. The granary area, at 85.2m sq, comprises a full 3 per cent of the total internal area (2.8 ha) (Gentry, 1976, 80-1).

In Area 3, the position of High Rochester at the junction of Dere Street and the Bremenium-Thrunton cross road, the reference to it having a mansio in the Antonine Itinerary,[1] its inclusion in Ptolemy's map to the exclusion of all other forts in Area 3, and its occupation from the Flavian throughout the Roman period suggests that it may have been an important fort, and possibly a 'holding depot' for forts in Area 3. Although not recovered within the fort, storage facilities may have been located extra-murally.[2]

Fodder. It is likely that a system of stations and inns throughout the North-east provided fodder and shelter for animals, as well as food and accommodation for travellers, so that transporting fodder or allowing the oxen to graze en route would have been unnecessary.

Mansiones and mutationes in the eastern and late Empire are described in much detail in the Theodosian Codex. Mansiones provided authorized persons with accommodation, post horses, draught and pack animals, and vehicles (Codex. 1.16.12; 7.1.9; 7.10.1), while mutationes provided relays of mounts and oxen.[3] Each station or inn provided fodder (Codex, 8.5.23.365; 11.1.9.365) through provision by either local

---

[1] If the Antonine Itinerary was indeed a collection of routes proceeding by mansiones (Chevalier, 1976, and below).
[2] Indeed, archaeological excavation has been focussed exclusively within the fort's defences (Daniels, 1978, 295-301).
[3] Procopius writes (Build 30.4) that as many as forty horses were kept in each.

communities or the provincial administration[1] as well as skilled staff. [2]

Some evidence exists in this survey area for mansiones. The Antonine Itinerary, dating from the end of the 2nd century at the latest, is a collection of journeys made or planned at different dates by different people (Rivet, 1969a, 67), presumably officials (Smith, R F, 1987, 18), and may have proceeded by mansiones (Chevalier, 1976, 185). If so, mansiones are listed at High Rochester (Bremenium), Corbridge (Corstopitum) and Binchester (Vinovia) in the North-east. However, the Itinerary may not be a complete list of mansiones in the North-east: many sites listed in one iter are ommitted in another covering the same stretch of road (Smith, R F, 1987).

Although archaeological evidence in Area 1 suggests only one mansio at Ebchester,[3] the evidence is much less sparse in Area 2. A building outside Benwell (Petch, 1928; Salway, 1984, 568; Burnham and Wacher, 1990, 37), the most notable building from the air in the Roman period

---

[1] Provincial revenues and levies exacted by the governor were used to build, maintain, and provision mansiones (Codex 8.5.34.377).
[2] Each station had a staff of carpenters to mend wagons, veterinary surgeons, and grooms (Codex 8.5.31.370).
[3] Salway (1965, 151) argues that a large mansio could be responsible for considerable surface indications noted by Hunter, 1721, 44.

settlement adjacent to the fort[1] at Chesters (Salway, 1965, 80), a building in the settlement adjacent to the fort at Vindolanda (Birley, R, 1977; Burnham and Wacher, 1990, 37), and a building at Corbridge have been identified as mansiones. The latter comprises three main periods of occupation, and was equipped with a hypocaust, courtyard, latrine, water supply (with the Lion monumental fountain built in the second phase), and walls with many coats of paint (Salway, 1965, 50-55; Burnham and Wacher, 1990, 37).

That these buildings shared a common official function is perhaps reflected in their respective locations. Benwell was for a period the easternmost Wall fort (discussed below, 6.3), Chesters is positioned at the North Tyne crossing of the Wall and Military Way, and Corbridge at the junction of Dere Street and the Stanegate. In addition, although pottery has been recovered in abundance at other parts of the Corbridge site, very little was found in the building thought to be a mansio. This lack of pottery may be explained either by inefficient data collection during its pre-World War 1 excavation (pers comm C M Daniels), or alternatively, because this is what should be expected if mansiones functioned as occasional lodgings: either these buildings were seldom

---

[1] As evidence attests to vicani living in vici at only two forts in the North-east (Vindolanda - vicani Vindolandesses (RIB 1700; and Housesteads - d(ecreto) vica(norum) (RIB 1616)), these terms are substituted throughout this thesis (unless referring to Housesteads or Vindolanda) with the more general terms 'civilians' living in 'settlements adjacent to forts', evidence for which is extant at nearly every fort in the North-east (discussed below, 6.2.3).

used or were kept very clean for important visitors (Burnham and Wacher, 1990, 37).[1]

At Newstead north of High Rochester in Area 3 along Dere Street, archaeological evidence[2] suggests a mansio:

> "It has been thought that in each period of occupation Newstead fort was furnished with one or more annexes or fortified compounds intended to house camp-followers or afford temporary shelter to convoys. Dr Curle recognized at least four of these, attached to every side of the fort except the [north] and often subdivided; [for example]...Outside the late Domitianic fort there was... an extensive courtyard building, resembling a house, which is best explained as a mansio..."
>
> RCAMS, 1956, 314

Mansiones, then, seem to be in evidence at seven forts in the North-east. As for the second part of the equation, the existence of mutationes in Britain is suggested by evidence at Bennaventa, mentioned in the Antonine Itinerary, and at Whilton Lodge, Northamptonshire (Dix and Taylor, 1988). This enclosure is 4-4.5 ha in area and straddles Watling Street, is defended by a quadrangle of earthen ramparts, and because of the absence of stone buildings, is thought to be a staging point only, without inn facilities (ibid.). Another candidate is at Thorpe-by-Newark (Burnham and Wacher, 1990, 38).

---

[1] Indeed, one common factor in all the proposed mansiones across Britain is the scarcity of broken pottery, coins and other trinkets (Burnham and Wacher, 1990).

[2] This structure is similar in plan to those of such large military houses as the praetoria of auxiliary forts or the tribunes' houses in fortresses, in which the rooms are ranged round a central colonnaded court (Salway, 1965, 170).

However, evidence for mutationes in the North-east is lacking. This may be explained by two things. First, it is possible that they simply have not yet been found (Burnham and Wacher, 1990, 38). Indeed, the proposed mansiones have been recovered because they lie near intensively-excavated Roman forts, and isolated mutationes along Roman roads in the North-east may still await identification. Second, the spacing of forts in the North-east simply may not have warranted construction of mutationes between the various forts. Indeed, the forts along Dere Street in the North-east were constructed at intervals averaging 16.3km[1] : at 3.2km per hour, a journey between two forts would have averaged 5 hours. Again, this represents the amount of time South African oxen are driven in one shift (Green, 1973). As for the Stanegate, forts were eventually constructed at 'half-day' intervals between the original forts (Birley, 1961, 6.2.1), and these later forts were perhaps mutationes in function if not in name.

Pack Animals. If a load could be divided equally between two panniers (Landels, 1978, 171-3), mules and asses could have hauled considerable quantities. For example, Egyptian papyri attest (Tengstrom, 1974, 16) to professional donkey-drivers transporting grain over short, sometimes long distances to tax-collectors: a driver could manage three donkeys, each carrying a sack containing three artabae (together about 19 modii or 168 litres) of grain. Even somewhat unwieldy cargoes could be managed by

---

[1] Piercebridge to Binchester: 14km; Binchester to Lanchester: 18km; Lanchester to Ebchester: 20km; Ebchester to Corbridge: 8km; Corbridge to Risingham: 24km; Risingham to High Rochester: 14km.

pack animal. Indeed, numerous ancient references attest to asses carrying cargoes such as firewood, poles, stakes, planks, and boards (Apuleius Met 7.7-24; Varro De Re Rustica 2.6.5).

As for load-carrying capacities, the ass is probably the same size today as it was in the ancient period (Leighton, 1972, 171-3), and World War 1 accounts attest to a carrying-capacity of 54kg (ibid.). Comparatively, a mule could carry during World War 1 90-120kg (ibid., 172). Using 100kg as the mean, 54 mules could have carried the same amount as one of the Piercebridge formula's river barges (5,340kg).

2.2.3 Cost

Arguments supporting the Piercebridge formula

The short distances possible in one day, as well as the small loads, combine to make overland transport very expensive (Selkirk, 1983, 83). In addition, instead of wages for just five men negotiating a Piercebridge formula barge, wages would have to be paid to twenty-four men transporting the same amount in ox-carts (ibid.).

In total, ancient literature supports this assessment of the high cost of overland transport. In the eastern and late Empire, it seems that long distance trade of bulky and relatively inexpensive commodities such as grain to civilian areas was profitable only when both the production area and market for the grain lay close to a port or navigable river

(Jones, A H M, 1973, 845ff). As for Cato's oil mill, the men transporting it worked for two sestertii per man per day, amounting to seventy two sestertii in wages per day (Cato de Agric., 12.3). In total, transporting the oil mill 40km would have cost 1/6 its original cost.[1]

Diocletian's Edict (1.1) also attests to the high cost of oxen transport. Wheat is listed at 100 denarii per cm,[2] and a wagon load (545kg) 4,000 denarii. A six day trip cost 2,000 denarii, which amounts to 333 denarii/day or one half the purchase price. Heavy but cheap articles were the most expensive goods to transport. Wood in a 545kg wagon load cost 150 denarii (Edict., 14. 8) so that after 11km, the haulage cost was equal to the original purchase cost of the material. On the basis of these figures, Duncan-Jones (1974, 366-9) has developed a ratio for transport costs in the Roman period by sea, navigable river, and land - 1:4.9:34-42.

Arguments Refuting the Piercebridge formula

However, overland transportation costs would not have been as great as argued above. Since land transport costs in Duncan-Jones' ratio are based on figures given in Diocletian's Edict, they are likely to be too high for the North-east. As discussed, the stipulations in the Edict were aimed at regulating transport in the mainly mountainous area around

---

[1] If Cato had purchased the oil mill in Pompeii 120km away for 384 sestertii the price would have doubled (Leighton, 1972).
[2] Castrensis modius = ca 13.6kg.

Nicomedia, and overland transport would have been easier and cheaper in less mountainous areas (Greene, 1986). At the conservative figure reached above of 26km per day, rather than 333 denarii at 10km per day, the cost of transporting the same amount of grain by ox-cart in the North-east would have been 333 denarii per 26km, or 42 per cent lower than the cost of transport reckoned by Cato and stipulated in Diocletian's Edict. Although the price of grain still would have been equalled in twelve days, carts could have been transported 2.6 times as far before equalling the cargo price, or 312km compared to 120km.

However, it must be kept in mind that transport of necessary items such as grain to forts in the North-east from long distances away was essentially a military problem, and therefore costs would have been borne by the state. By the Late Empire, transport of essential foodstuffs and other items to the forts had become the responsibility of the cursus clabularis of the cursus publicus, a state institution drawing on Imperial funds.[1] Some such official system is expected for the collection of annona set up under Severus, and as for the earlier Empire,

---

[1] This system was probably begun under Augustus and was originally designed for official dispatches (Hammond and Scullard, 1970). By the time of Theodosius, the management of the service had devolved to praetorian prefects and provincial governors, and the service itself had been divided into two services; the cursus velox (express post), and the cursus clabularius (wagon post) (Codex, 8.5.16.363). The first provided saddle-horses, pack-horses for luggage, light two-wheeled carts drawn by three mules, and four-wheeled carts drawn by mules, eight in summer and ten in winter, conveying officials travelling on business, as well as valuable goods such as gold and silver. The latter system, using wagons with two pairs of oxen (Codex, 8.5.2.360) conveyed foodstuffs levied for the annona, uniforms and arms for the troops, and timber and bulding stone for public works (Jones, A H M, 1973, 831).

it is possible that such a system existed but was organized on a more ad hoc basis, or perhaps was merely unarticulated in ancient literature (discussed below, 6.2.3). Even if the supply of essentials was left rather to private enterprise than to an official system, the state ultimately would have been responsible for the cost. Therefore, wages and the overall cost of transport would not necessarily have impeded the supply of goods to forts along the road systems over long distances.

For pack animals, Diocletian's Edict states that an ass cost 1 1/3 denarii per 45kg over 1.6km, compared to 1 2/3 for the ox-cart (Leighton, 1972, 159). Mules were also much cheaper than ox transport (Edict 1.7.25). For example, wool could be transported 300km by mule for only a 10 per cent price increase. The strongest point in favour of the cost of transportation by pack animals is the fact that several could have been linked together or driven in a group, eliminating the wages of many men. A string of twenty mules (Greene, 1986, 39) could have transported 2,000kg cargo 80km in one day, while three teams of 20 mules each could have transported more cargo than a Piercebridge formula barge carrying 5,340kg.

2.2.4 The Character of Roman Roads

Arguments supporting the Piercebridge formula

Roman roads were not used for the transportation of heavy cargo because they were designed for and used by the military and cursus publicus: if forts were supplied by ox-carts, these specialized roads would have been clogged with transportation of slow moving vehicles, rendering quick transportation impossible (Selkirk, 1983). Leighton agrees (1972, 161):

> "...the Roman roads, solid, substantial, and expensive to build, were primarily military in purpose and did not provide surfaces or gradients congenial to land transport."

In addition, since Roman roads ascend hills at far steeper gradients than Medieval or modern counterparts, which switch-back or skirt the same hills, Roman roads were used only for light traffic, while heavy supplies were transported by river barge (Selkirk, 1983).

Arguments Refuting the Piercebridge formula

That Roman roads across the North-east were "crammed with slow supply wagons" thus inhibiting military movements (Selkirk, 1983, 73) is highly unlikely. First, Roman roads across the North-east are wide: excavation of the Devil's Causeway along a number of stretches (see Appendix J-1) attests to its 6-8m width. These roads, then, could have accommodated three and possibly four clabularia abreast.

In addition, as discussed below (6.2.3), many supplies would have been gained on a local level. In these cases, the native population would have made use of trackways in existence before the Roman period. Such roads are suggested by reference to chariots by Caesar (B Gall., 4.24.33), and by much evidence suggesting a strong and skilled tradition of Celtic cart construction (Chapman, H, 1982, 192). Local supply may have devolved upon native trackways, while only longer distance supply was carried out over the Roman trunk roads.

The quality of Roman roads may have allowed transport of heavy vehicles even up the steepest gradients. As discussed in Appendix J-1, excavations in three different areas of the Devil's Causeway have revealed impressive engineering, including large flat blocks forming its foundation, a surface in some places of sandstone and limestone cubes, in other places sandstone blocks or gravel, sandstone block kerbs, and sometimes a central rib. These accommodating and well-maintained surfaces with excellent drainage would have been easier to ascend, even

with their steep gradients, than roads of other periods with shallower gradients. Indeed:

> "the existence [in the Roman period] of a powerful central government, combined with local civic responsibilities, probably avoided some of the ludicrously uneven conditions of 18th century English roads, where routes of major national importance could change from well-made turnpike roads to quagmires".
>
> Greene, 1986, 40

Finally, a system of holding depots described above may have allowed smaller shipments of goods, so that the steep gradients would not have posed difficulties.

2.2.5 Discussion

The Piercebridge formula model of overland transport is inadequate. Oxen could have hauled carts 2.6 times further, while pack animals could have carried in one day certain cargo over 8 times the distance estimated for overland transport in The Piercebridge Formula.

In addition to maximum distances, weight stipulations were also biased towards the mountainous roads of the Mediterranean basin, and carts could have hauled greater quantities of heavier cargo, such as raw materials, across the North-east. As for supplies such as grain transported at least in part over long distances, it is possible that certain forts functioned as 'holding depots', which would have allowed light shipments over short distances. Other supplies which could be divided into two

panniers could have been carried quickly by pack trains. In addition, it does not seem that fodder would have been transported in addition to the cargo. Fodder would have been stored at each fort, whether or not equipped with a mansio, as animals attached to each fort would have required a stored food supply (discussed in Appendix H-1.2). Furthermore, the distance between most forts in the North-east would not have exceeded a single 'stage' of transportation by ox-cart or pack animals, so that stations between forts providing fodder may not have been necessary. Therefore, estimates in The Piercebridge Formula which include transport of fodder are inflated.

All of these together allow an estimate of overland transport costs well below that stated in The Piercebridge Formula. Ox transport would have been at least two fifths the cost, and pack animal transport vastly more cost efficient than ox-transport.

In short, wide Roman roads together with the use of native trackways negate the image of roads crammed with slow moving vehicles. In addition, the high quality of Roman roads and provision of holding depots allowing smaller loads would have enabled ox-carts to surmount the sharp inclines of Roman roads more easily than argued in The Piercebridge Formula.

2.3 CONCLUSION: THEORY

The use of static barriers on the rivers of the North-east in the Roman period would have been very inefficient. The highly-gradated rivers of this survey area would have required construction of at least 199 dams. Each of these dams would have affected detrimentally the regime of their respective rivers, so that the Piercebridge formula system would have required much maintenance over the entire river system. Such construction and maintenance would have been <u>in addition</u> to the construction and necessary maintenance of the road system. Not only are such roads attested archaeologically across the North-east (discussed below, 6.2.1), roads used for troop movements and short distance transportation are in fact necessary components of the Piercebridge formula (Selkirk, 1983). In addition, negotiating the dams would have required an efficient lifting device. The pound-lock was probably not known in the ancient world, and in any event such closed systems would have severely aggravated the siltation process of a river regime. The only alternative to a closed system is the flash-lock: however, the time necessary to negotiate a river equipped with flash-locks would have rendered the system tediously slow and inefficient.

Conversely, the combination of straight, wide, well-constructed Roman roads equipped possibly with inns and forts functioning as 'holding depots', allowing swift, short journeys of wheeled traffic or pack animals, and ox-teams able to pull carts more swiftly over greater distances, with heavier loads, and far less expensively than argued by

Selkirk, renders overland transport of supplies in the North-east far more efficient than envisaged in his The Piercebridge Formula (1983).

In short, the same amount of cargo as that transported to High Rochester from Stella on the Tyne by one Piercebridge formula river barge (5,340kg) along rivers equipped with flash-locks, requiring eighteen days, could have been transported the same distance overland (82km) by five ox-carts in four days, or three teams of twenty mules in two days. As Piercebridge formula river transport would have been much less efficient, and overland transport much more efficient than argued in The Piercebridge Formula, it is highly unlikely that Roman period rivers of the North-east would have been developed according to the Piercebridge formula.

CHAPTER THREE

EVIDENCE: AREA 1

Having assessed its theoretical basis, it is now to discuss evidence for the Piercebridge formula. Ten sites across the three areas of the North-east will be examined over the next three chapters. At each site, a brief discussion of the evidence supporting the Piercebridge formula will be followed by evidence refuting the formula. Chapter 5 will conclude with a general discussion of the evidence.

The River Tees marks the southern boundary of Area 1 and this survey area. From Piercebridge, 30km above the tidal mark of the Tees, Dere Street runs north across the Pennine Spurs, where it descends into three successive river valleys. Within these valleys the road is protected by Binchester fort on the Wear, Lanchester on the Browney, and Ebchester on the Derwent. Dere Street then crosses the Tyne into Area 2. East and parallel to Dere Street another road runs through the coastal plain from the Tees to the Wear at Chester-le-Street fort, and continues north until it joins the Wreckendike just south of the Tyne.

The first site examined in Area 1 is Piercebridge, the prototype site of The Piercebridge Formula, followed by Chester-le-Street and Binchester.

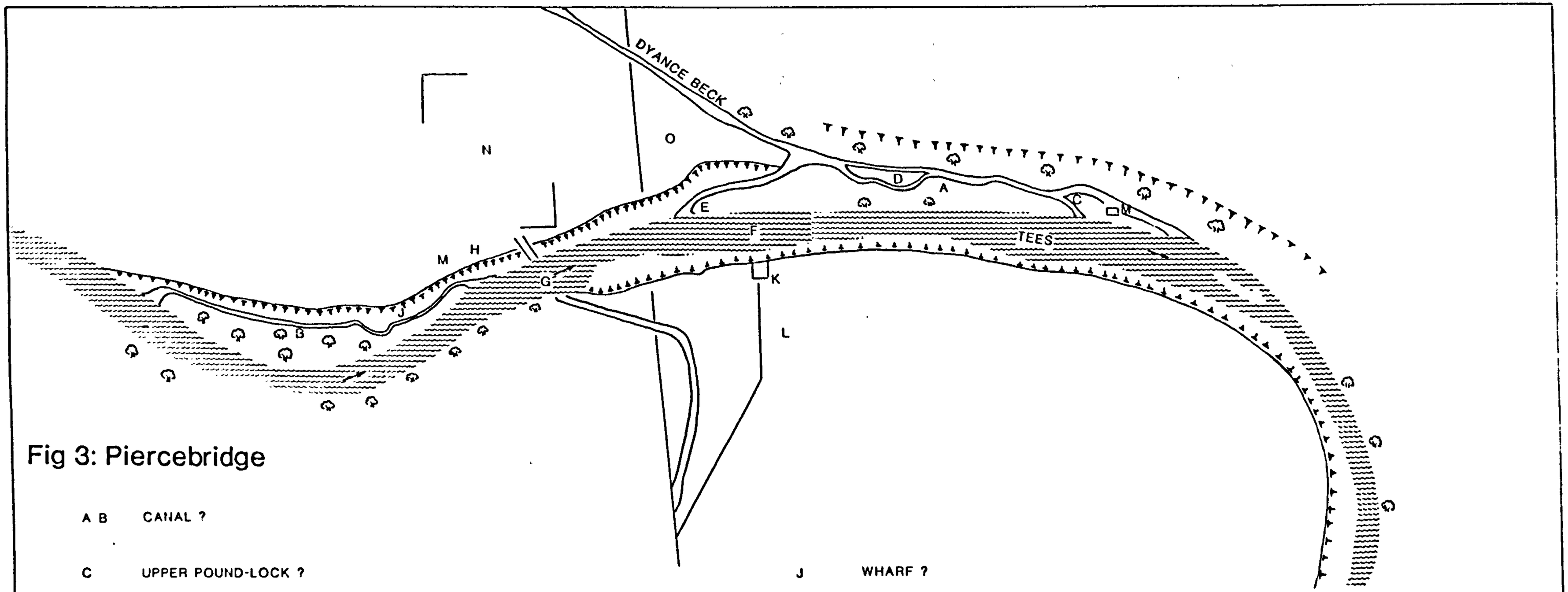


Fig 3: Piercebridge

A B	CANAL ?	J	WHARF ?
C	UPPER POUND-LOCK ?	K	ABUTMENT
D	PASSING-PLACE	L	SETTLEMENT
E	LOWER POUND-LOCK ?	M	MILL
F	DAM ?	N	FORT
G	ROMAN BRIDGE ?	O	TOFTS
H	HARBOUR ?		

3.1 PIERCEBRIDGE

The modern village of Piercebridge, County Durham, lies mainly inside the walls of a Late Roman auxiliary fort, dating ca 260-270,[1] on the north bank of the River Tees. East and adjacent to the fort lies a settlement, dating perhaps to the 1st century AD, and Dere Street, crossing the Tees south of the fort and continuing through the settlement. Although conclusive evidence is lacking, 1st century material found within the settlement suggests an earlier period fort somewhere at Piercebridge (Higham, 1986, 222). Indeed, given its vital position at the Dere Street crossing of the Tees (discussed below, 6.3), a fort is likely to have existed at Piercebridge throughout the Roman period (ibid.).

However, instead of protecting this crossing, it has been argued that the fort was placed near the river in order to facilitate its provision by barges navigating the Tees (Selkirk, 1983, 109):

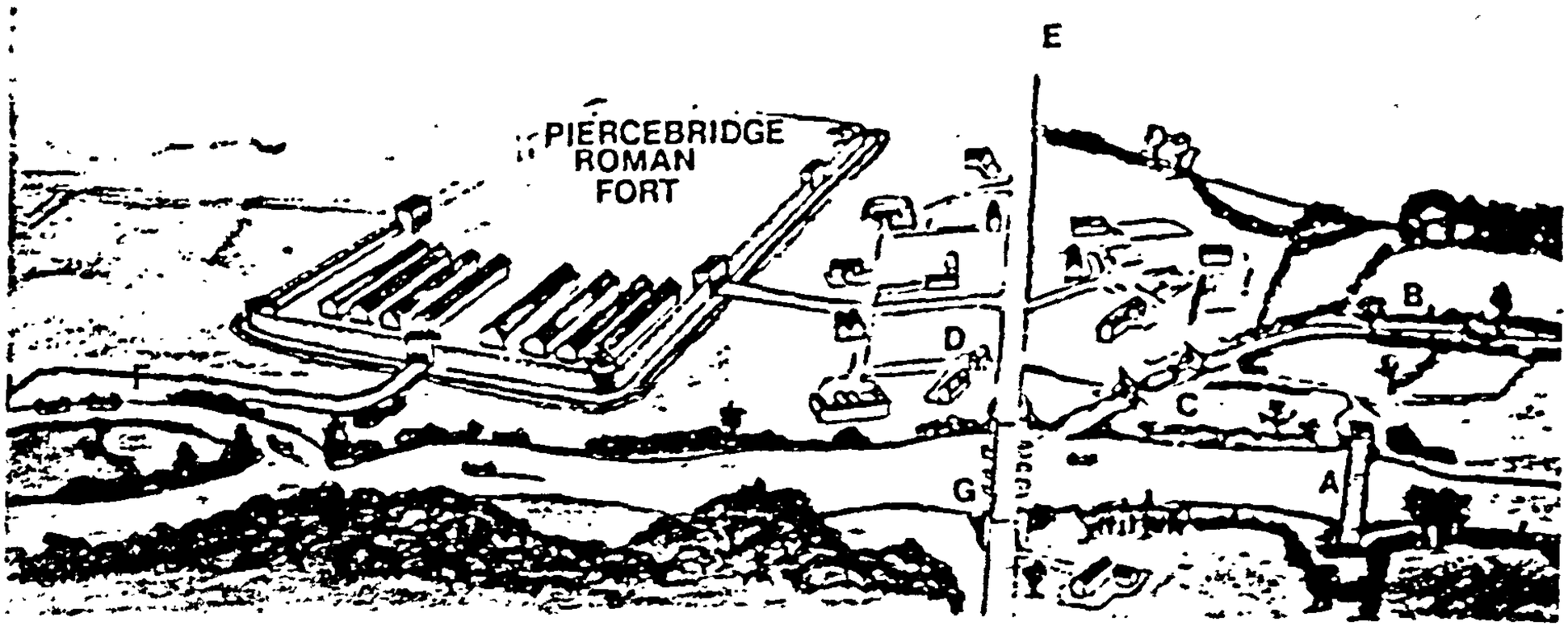
> "...I could see the whole picture; an inland Roman port on a major north-south road; barges coming up from the sea where they had picked up cargoes from merchant ships; these barges ascending dams via pound-locks, either in the dams, or in short by-pass canals around the ends of the dams; the barges arriving at Piercebridge harbour and the cargo being discharged into ox-wagons for local delivery. It all made sense, and Piercebridge was to become my prototype 'water supplied Roman fort'."

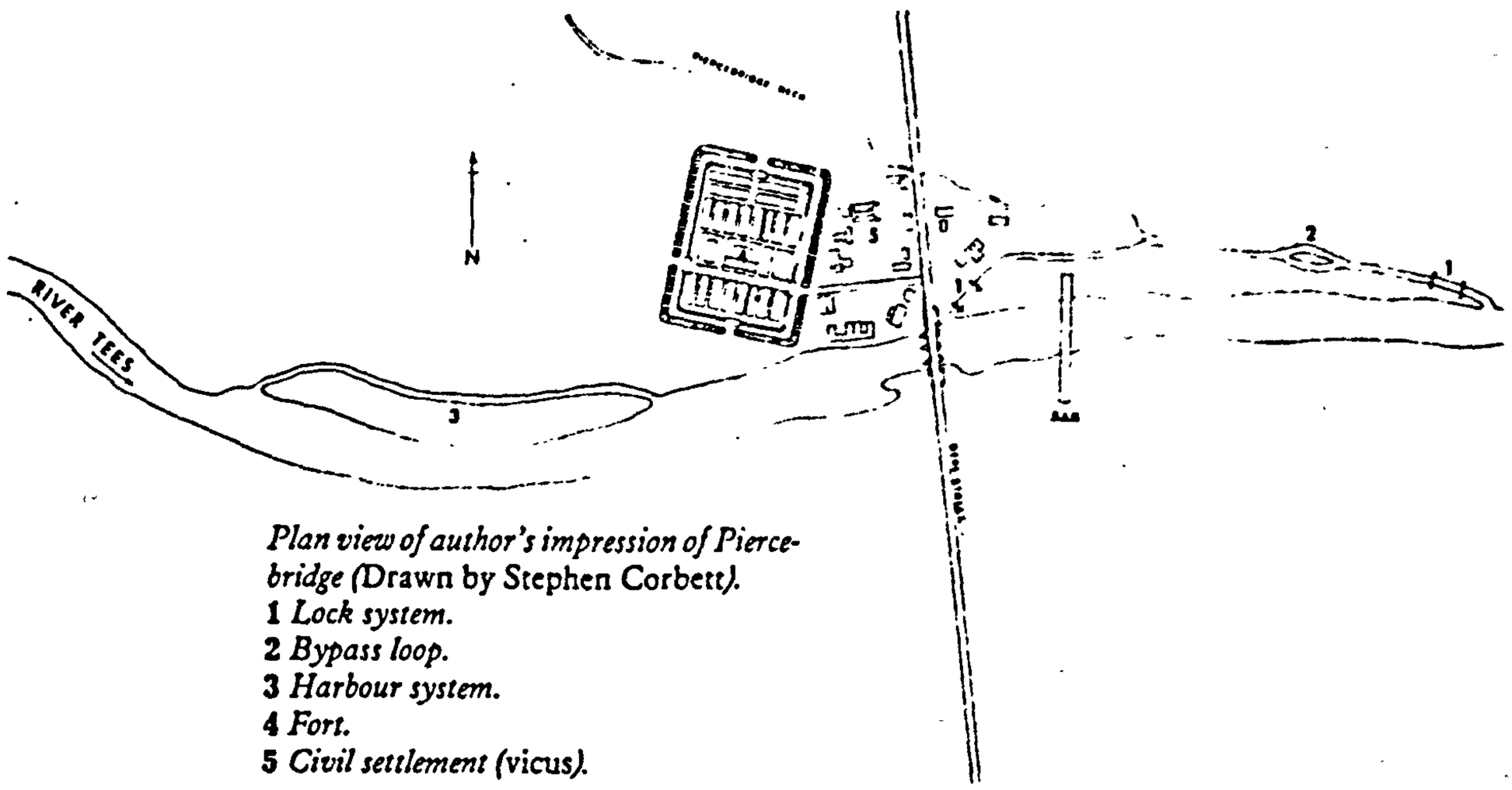
---

[1] This estimate (Scott, 1978, 21) is based upon the recovery in recent excavations of over a thousand coins on the site.

Fig 4: Piercebridge According to Selkirk, from Selkirk, 1983, 109, 111, 112.

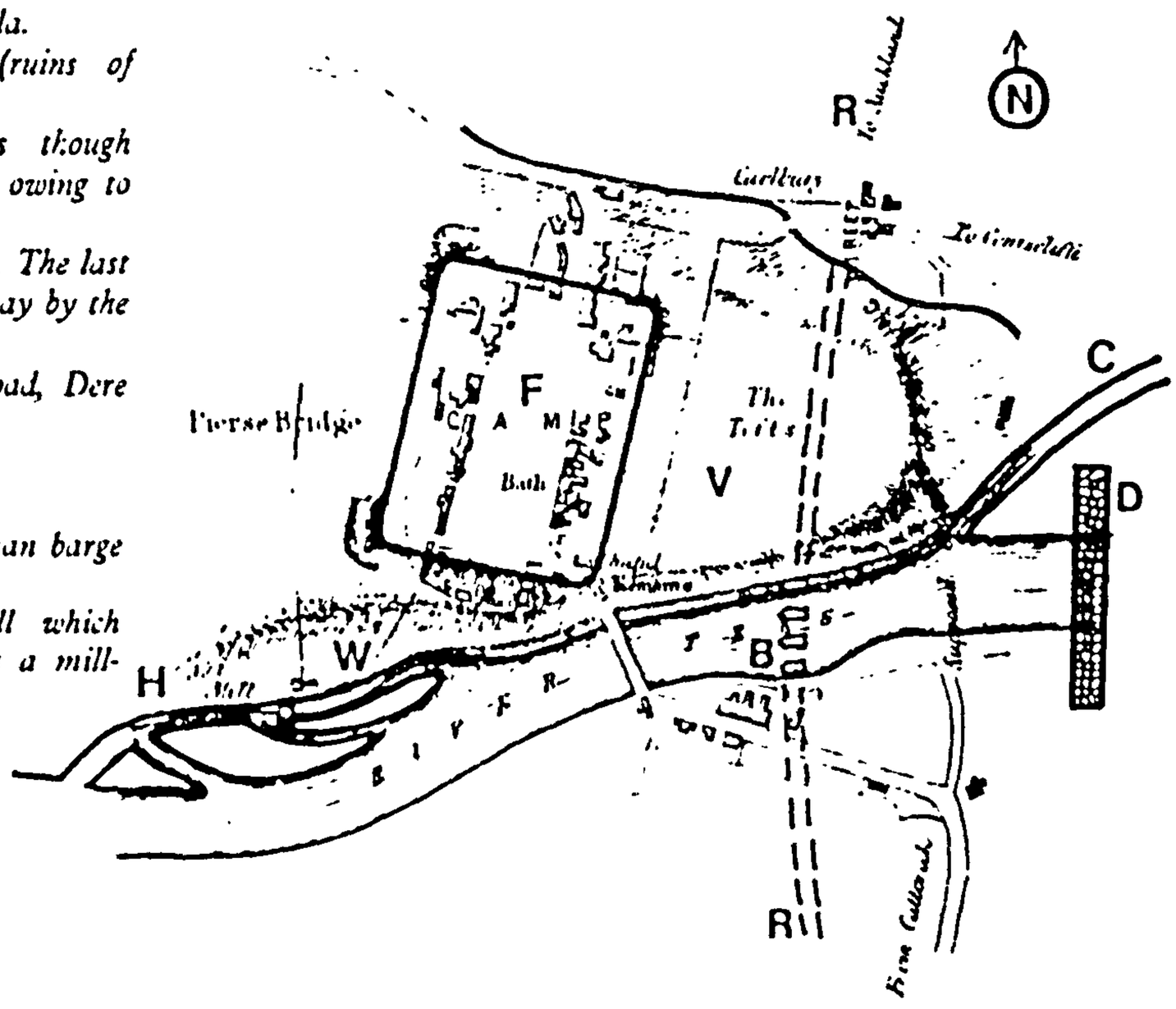
The author's impression of Roman Piercebridge.
A *The Roman dam.* **B** *The bypass-canal.* **C** *A pound-lock.* **D** *The* vicus. **E** *Main roman road to the north (Dere Street).* **F** *Roman harbour.* **G** *Roman bridge.*





Plan view of author's impression of Piercebridge (Drawn by Stephen Corbett).
1 *Lock system.*
2 *Bypass loop.*
3 *Harbour system.*
4 *Fort.*
5 *Civil settlement* (vicus).

The Piercebridge Formula.
D *Navigation dam (ruins of southern end survive).*
C *Canal, still exists though normally high and dry owing to destruction of dam.*
B *Site of Roman bridge. The last remains were washed away by the great flood of 1771.*
R *The main Roman road, Dere Street.*
F *Roman fort.*
V Vicus.
H *Site of suspected Roman barge harbour.*
W *Mediaeval watermill which used Roman harbour as a mill-race.*



3.1.1 Evidence Supporting the Piercebridge formula

By-pass canal

A cutting in the north bank of the River Tees above the present river level east of Tofts Field represents a by-pass canal (Selkirk, 1983, 100). Although marked on the OS map as a mill-race, this feature is "too vast" at 4m wide for that to have been its original purpose (ibid.). The canal leaves the Tees at NZ 214517 and runs for ca 65m until it rejoins the Tees at NZ 219517. The by-pass canal also contains two pound-locks and a barge passing-place.

Near the channel's entrance after leaving the Tees, a passage "revetted with Roman-type ashlar" represents the upper of two pound-locks (Selkirk, 1988a, 42).

About "half-way along", the canal splits into two channels, the right hand channel representing a barge passing-place (Selkirk, 1988a, 42).

A lower pound-lock is situated at the downstream end of the canal, at a point before the canal re-enters the Tees (Selkirk, 1983, 100). Within this structure is stonework with "typical Roman feathered toolmarks", as well as two slots for a guillotine gate in a stone-lined passage. These slots, 34cm wide, 26cm deep (see plate 3), have been joined by a similar, but timber-lined slot beneath the water surface.

Dam

Discovered in 1972 during gravel-digging operations, a structure on the south bank of the river west of the channel and east of the modern bridge (see plates 1, 2), which has been regarded hitherto (Scott, 1982) as the second of two Roman bridges at Piercebridge, is in fact a navigation dam (Selkirk, 1983; 1988a).

This reinterpretation is justified as follows. First, it does not conform to the standard, structural requirements of a bridge, its essential components being too small. A structure identified as an abutment (Scott, 1982) on the south aspect of the excavated area, at 8.03m long, 3.07m wide, and 1.2m high, a causeway running along the eastern aspect of the excavated area, and pavement over which the structures were constructed, ca 80m long, 13m wide and one slab thick, are too frail to have supported stone Roman bridge piers (Selkirk, 1988a, 45; see plate 2). Further, the circumference of a hole in the pavement suggests that the piers would have been too small to hold a bridge. In any case, the causeway and pavement are without precedent in Roman bridge building (see plate 2): Roman piers stood independent of each other, resting on bedrock or in piles driven into the river beds, rather than on platforms.

In addition, angled slots cut into the vertical northern face of the abutment only half a metre above the pavement would have been too low for bridge support timbers, and were rather meant to take upward sloping

timbers for a footbridge (Selkirk, 1988a, 44; see plate 2).

Finally, the position of the structure 100m south and 4m above the present course and level of the river negates the suggestion that it functioned as a bridge. As the bed of the river consists of .5m boulders and gravel over solid rock, the Tees would not have incised this deeply since the Roman period. If so, it would have cut at more than 10 times the rate of the Colorado river, which has incised only 1ft (30cm) over 2,000 years (Selkirk, 1983, 103).

These structures and features are, however, consistent with a dam (Selkirk, 1988a, 51). The abutment, causeway, pavement, and slots together comprise a flood spillway. The abutment represents the southern end, and since it was supporting only the water of the spillway, the floor required paving only one slab thick. As for the causeway, this was a balustrade containing cataractae which "would have given the Romans a fine control of the water level for navigation upstream", in addition to providing a stop-gap against periodic flooding. The slots in the abutment and the rectangular holes in the pavement would have held timber supports for a small timber footbridge constructed across the spillway (ibid.). The footbridge would have incorporated windlasses, which could have raised or lowered cataractae built into the spillway, so that water levels above the spillway could be controlled (ibid.).

The dam is also positioned perfectly. It is about half-way between the entrance to the channel and the point at which it re-enters the Tees.

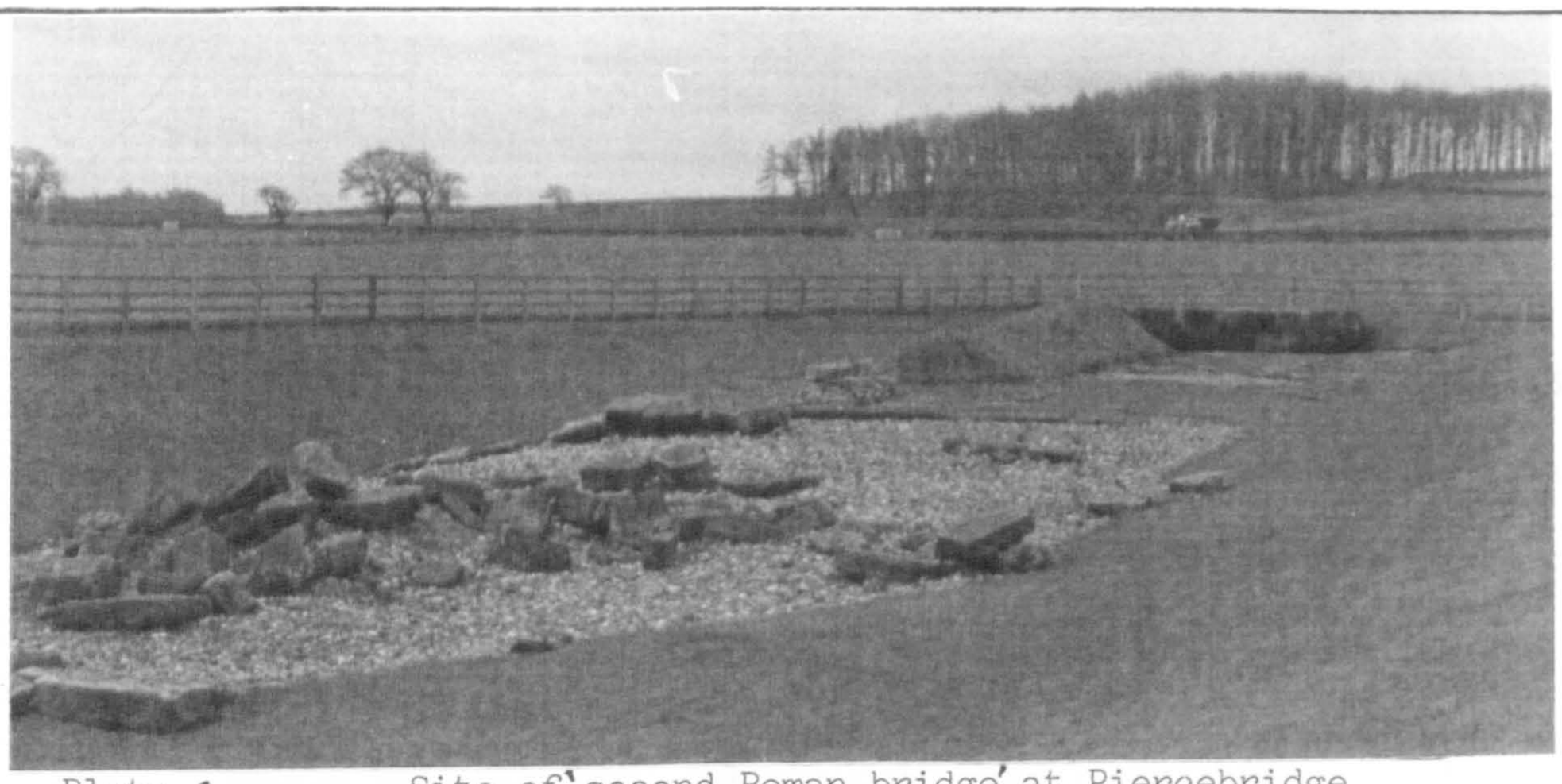


Plate 1 Site of 'second Roman bridge' at Piercebridge

Plate 2 'Bridge abutment' at Piercebridge

'Causeway' on second Roman bridge at Piercebridge

In addition, its position well into the bank is consistent with a dam functioning to prevent peripheral scouring (Selkirk, 1983, 100). Finally, the flood spillway would have been the right height (Selkirk, 1988a, 48): by ponding the river upstream to a point 3m above normal, it would have facilitated navigation upriver, and flooded the by-pass canal on the opposite bank (ibid.).

Bridge

Artefactual evidence suggests that a bridge situated at NZ 213156[1] carrying Dere Street over the Tees was used during the entire Roman period (Selkirk, 1983). As the artefacts[2] were found between boulders in two lines across the river bed near the bridge, it is likely that they were thrown from the bridge. This is also suggested by the large proportion (over fifty per cent of the total) of silver coins recovered: the silver coins, as well as certain other types of artefacts such as figurines (see plate 9), are likely to have been votive offerings. As ceramic evidence consists of Flavian samian through to Crambeck ware, and as the coins (over sixty have been recovered) also span the same period,

---

[1] Stone piers were visible above the water surface before the great flood of 1771 (Wooler, 1917), as were wooden piles after 1771 (Hutchinson, 1794, 214). In 1915, various large stones, including a 'coping-stone' and wedge-shaped stone were found under the water surface (Wooler, 1917). By 1933, several oak piles were found under the surface, consisting of two large concentrations, thirty-two altogether, with cross members found buried in the mud (YAJ 31, 1934, 385).

[2] These include ceramics, coins, brooches, rings, lead seals, scales, nails and large spikes, figurines, drawer handles, lucky charms, pins and needles (pers comm R Selkirk).

the bridge must have been in operation throughout the Roman period. The continued use of this bridge renders a 'second bridge' downriver redundant, so that the downriver structure is therefore, by default, a 'dam'.

Barge Harbour

Another cutting upriver from the bridge and south-west of the fort represents a barge harbour. Although used later as a mill-race, the channel is "far too vast" to have been constructed originally for this purpose (Selkirk, 1983, 108). Rather, the channel, 'V'- shaped, ca 5.5m wide, 1.5m deep, and south-west of the fort is in a perfect position to have facilitated access for barges to the fort (ibid.).

Barge wharves

Finally, channels deviating from this barge harbour back to the river represent barge wharves. As they do not fit into the context of a Medieval mill, it is argued that these structures must belong to the Roman period (ibid.).

Plate 3 Masonry in 'upper pound-lock', Piercebridge

Plate 4 Masonry in 'lower pound-lock', with guillotine slot, Piercebridge

3.1.2 Evidence Refuting the Piercebridge formula

By-pass canal

The nature of construction and position of the by-pass canal, including the structures which it contains - the pound-locks and barge passing-place, suggests against a Roman period construction date.

Nature of construction. The stone structure located ca 15m along the by-pass canal after leaving the Tees is too narrow to have functioned as an 'upper pound-lock'. As the structure is only ca 2m wide at the top (1.2m deep and 5m long), a bargeman navigating a Piercebridge formula barge 2.1m wide (Selkirk, 1983, 83) would have been unable to negotiate this 2m wide section. Even the narrower Hasholme log-boat recovered in pre-Roman contexts in Yorkshire (discussed below, 6.3.1), which is 1.4m wide, would have been a tight fit.

In addition, the stones do not have "typical Roman feathered tooling marks" as described. Close analysis of Roman period worked stones at Chesters and Corbridge reveals that Roman feathers have:

> "closely-set elliptical lines, cut with a fine point which curve in opposite directions, from the centre of the face at the top, towards the lower corners of the block. The upper edges of these blocks are often cut back to a flat surface by a depth of up to 40mm".
>
> Bidwell and Holbrook, 1989, 117

However, the stone in the 'upper pound-lock' has regular, short marks set

Plate 5 Bottom 'pound-lock', Piercebridge

Mill race on left, bottom 'pound-lock' on right, Piercebridge

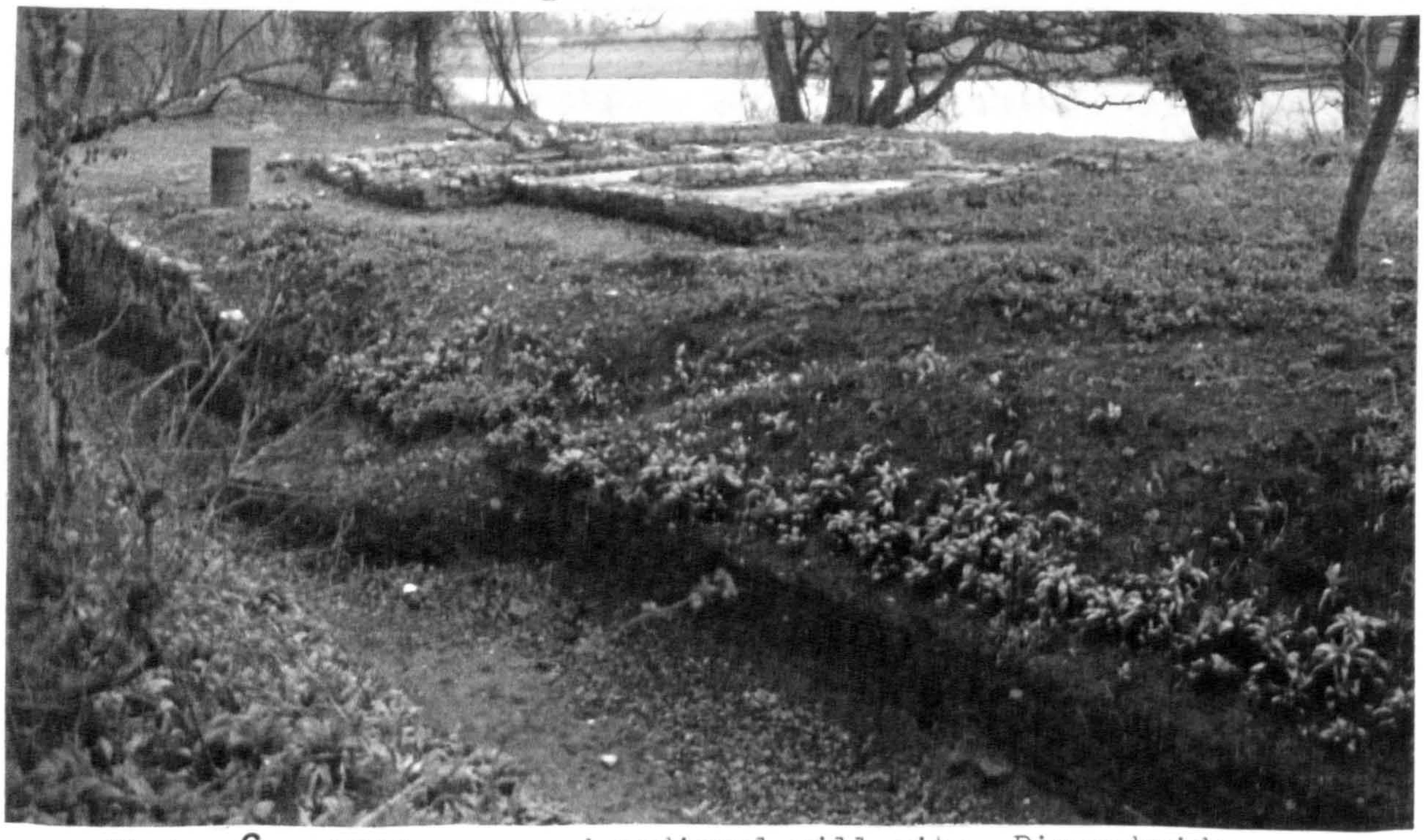


Plate 6 Mill race and medieval mill site, Piercebridge

in diagonal grooves in a series of drafts, with carefully-worked beds and joints. This type of masonry is 'boasted' rather than feathered: boasted stone-working is common to many different periods, and is not specifically Roman (Hill, 1981, 2-3).

Further, the masonry constrasts in style with the known examples of Roman period water-works at the 'dam' site across the Tees. Although the 'pound-lock' masonry is small, smoothly-cut and tight-fitting, the 'dam' masonry is far larger (compare plates 2 and 3). Perhaps more important is the difference in the condition of the masonry at the two sites: the 'pound-lock' masonry is much more pristine than the 'dam' masonry. However, the opposite is expected: unlike the 'dam' which was found buried under a protective layer of sediment, the 'pound-lock' would have been exposed to erosive elements such as rain, wind, and the flooding action of the Tees.

After the 'by-pass canal' joins the Dyance Beck (NZ 216 158) ca 300m from its mouth, a second channel begins and runs parallel to the 'by-pass canal' for ca 200m, forming the 'barge passing-place' (see plate 7). However, this seems rather a natural feature. Indeed, about half-way along its length a large 'S'-shaped bend meanders several metres from side to side (see plate 8). Such a meander is inconsistent with a barge canal, and it seems that this channel represents a former meander of the Dyance Beck through which a later channel was cut (discussed below).

Plate 7 'Barge passing place', Piercebridge.

Plate 8 Meander in 'barge passing place', Piercebridge.

About 50m from its terminus, the channel enters the 'lower pound-lock'. Again, at ca 1.8m wide, 1.6m deep, with opposing faces of differing lengths, this channel seems much too narrow to accommodate anything but a very small barge. In addition, the stone appears to have been cut sometime in the post-Roman period (see plate 3). The north and south faces are ca 7m and ca 1m respectively, and for the greater part are of unworked stone, while the leading sections are of dressed stone, similar to the stonework in the 'upper pound-lock'. Similarly, this stone is well-cut and tight-fitting, and again, smaller and in much better condition than the 'dam' masonry across the river.

Position. Because the 'by-pass canal' meets the Beck, it is unlikely that it was ever constructed for the purpose suggested in The Piercebridge Formula. Chronic flooding of the Beck occasionally inundates the north end of Piercebridge village and nearby Carlbury Vale today, and evidence suggests (Scott, 1977, 6) that this also occurred at the northern end of the fort during the Roman period. The object of closing a system with pound-locks on either end would have been to regulate water levels within the channel, and the flooding of the Beck into the channel would have upset this balance. In addition, given the flooding of the fort, it is unlikely that steps would have been taken which would have further aggravated a flood-prone system. If constructed anywhere, it is more likely that a Roman period canal would have been built simply skirting the dam, avoiding the unpredictable Dyance Beck (Coupland, 1987).

Second, the channel does not follow a steady gradient (ibid.). The upstream course falls gently, while a sharper descent begins from the upstream edge of the 'lower pound-lock' into the Tees. A pound-lock on the shallow gradient of the first course of the channel would have been superfluous, while the steeper gradient at the bottom of the channel would have necessitated more than one lock. Again, if simply skirting the dam, or incorporating a lock into the dam, only one lock would have been necessary, rather than the many needed for the 'by-pass' canal.

Rather than for navigation, Coupland argues (1987, 4) that the 'by-pass canal' was cut in the first place as a Medieval mill race. A sluice gate in the 'upper pound-lock' could have regulated the flow of the Tees' water entering the channel, especially in times of flood. A meander in the Dyance Beck was by-passed so that the race would follow a straighter course, thus leaving a palaeo-channel of the Beck, or the 'barge passing-place'. The lower course of the channel consists of two passages: the passage with the 'lower pound-lock' runs south of another, since blocked, which served as a race for the Medieval mill (see plate 6). The southern channel functioned as a by-pass channel: after closing the sluice gate, the full amount of water in the channel would have been directed towards the mill (ibid.). When the Beck flooded, some water could have been diverted down the southern channel by an open sluice gate, thus alleviating upstream flooding.

Also, the channel's grade of descent would have turned a mill very efficiently. The shallow descent of the first area would have kept the

water within its banks, while the steeper fall over the last 50m would have increased the water's velocity before turning the mill (ibid.).

Dam

As mentioned, the 'dam' has been argued hitherto as the second of two Roman bridges. This structure indeed may have been in a suitable position for a bridge in the Roman period. Rivers move laterally and vertically, and depending upon the nature of the river and bed, sometimes to a large extent. As discussed (2.1.2), the major river valleys of Area 1 probably were cultivated extensively in the Romano-British period, so that the Tees would have been charged and governed to a great extent by large amounts of sediment: it would have been wide, shallow, and sluggish. A certain degree of lateral movement of such a river is not only understandable, it is expected.

Scott argued (1982, 77) that the river shifted to the north during the Roman period, and has continued to do so. Indeed, excavations have shown that soon after the structure was completed, silting began at its southern aspect (1982, 77), so that by the late 3rd-4th century the water channels between at least the first three piers had silted up (Bidwell and Holbrook, 1989, 112). Since the Roman period, the whole site has been buried under 3-4m of sediment and gravel (ibid.).

Vertical movement has been the result of a relatively recent decrease in cultivation taking place along the Tees catchment. Less sediment

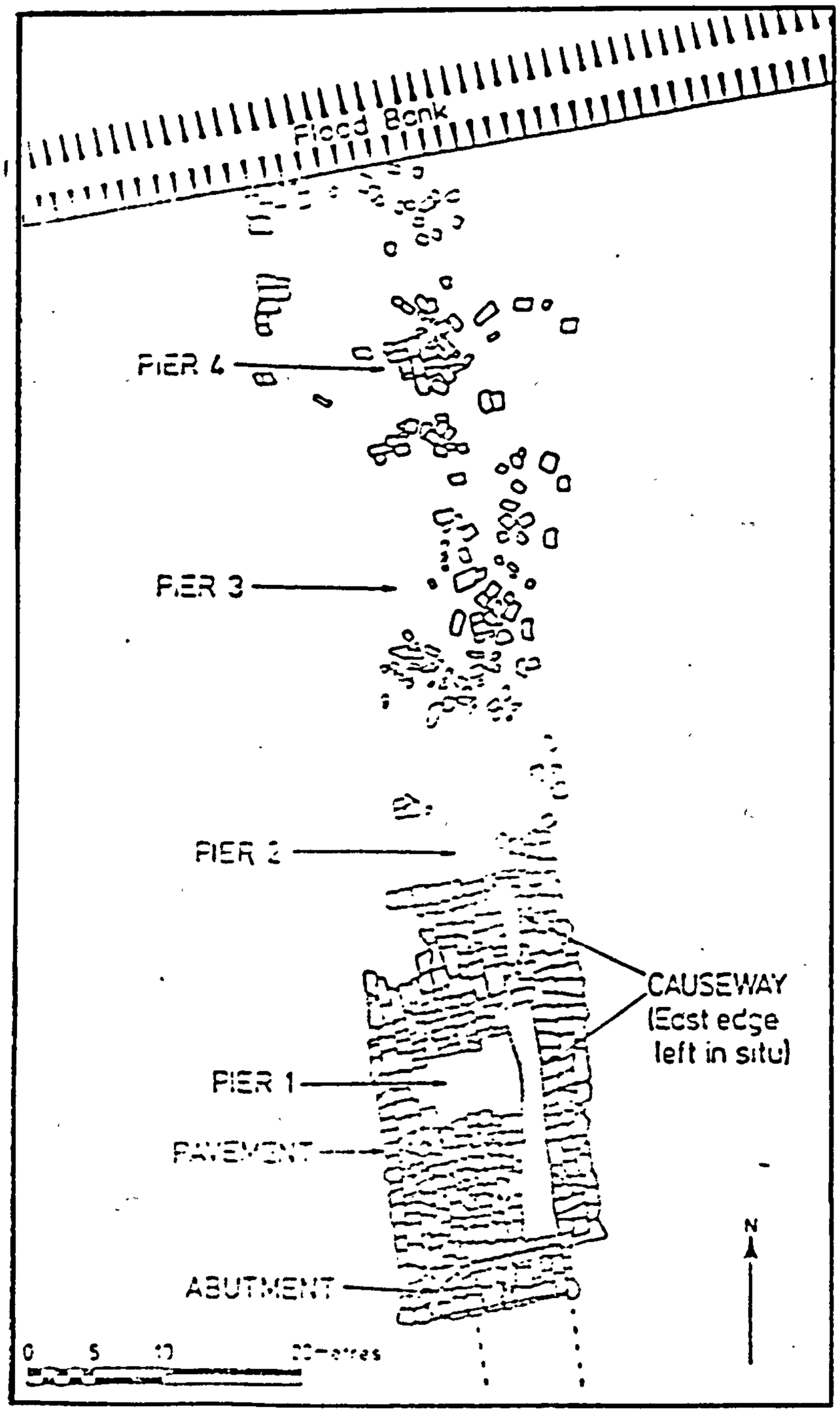


Fig 5: The second Dere Street bridge platform, from Scott, forthcoming.

concentration has resulted in a faster river prone to incision. Unlike the Colorado River cutting through the bedrock of the Grand Canyon, the recent incision of the Tees has taken place through soft river alluvia deposited in previous periods of high alluviation rates. Given their dramatically different templates, incision rates of the Rivers Colorado and Tees are not comparable.

In addition to its position, its construction also seems that of a bridge. Pier 4, its 4.53m wide base recessed slightly into the top of the slabs, has a squared side downstream and a cutwater upstream (Bidwell and Holbrook, 1989, 112): a cutwater is incongruous with a dam structure meant to hold back water (see figure 5).

The pavement also conforms well to that expected in a bridge context. First, such a pavement is not without parallel, as similar paving is found at Chesters bridge (Bidwell and Holbrook, 1989, 11). Second, held together under Pier 4 by iron bar clamps, the pavement would have been strong enough for its intended function: that is, to prevent the scouring action of the river from undermining the piers (ibid., 112).

At 6.1m wide and consisting of a revetment of dressed blocks, the causeway's function can be explained in terms of river action. After the above-mentioned shift in the Tees' course during the Roman period, the southern end of the bridge was reconstructed. The masonry of the first two piers was removed (along with the underlying areas of sandstone pavement), the abutment was demolished down to its second course, and a

causeway was constructed above the alluvia (Bidwell and Holbrook, 1989, 112). This probably functioned as the base of a ramp to carry Dere Street towards the bridge (ibid.).[1]

As two of the slots in the abutment were unfinished, it is likely that all were unused (see plate 1). They may have been constructed to hold wooden beams for one of two purposes: to serve as the centreing for stone arches, or as diagonal supporting struts for longitudinal timbers of the superstructure (ibid.). However, probably because they were too low, they were re-cut on one of the higher courses of the abutment which was removed later (ibid.).[2]

Scott argues (1982) that this structure was constructed when the first bridge 200m upstream collapsed or was destroyed. The bridge was re-sited because the original site, set between two steep banks, rendered the bridge vulnerable during periods of flooding: at such times, water would rise between the banks and exert destructive pressure upon the bridge infrastructure. The new bridge would span a wider, shallower, and less forceful river. The sequence of events may have been as follows.

---

[1] Similarly, a substantial concrete causeway has been found approaching the bridge at Lincoln, consolidated with rows of wooden piles (Dymond, 1963, 152), while at Aldwincle in Northamptonshire, timber piles were found in 1975 leaning inwards on the downstream side of a Roman bridge, possibly representing some kind of weir or causeway (Jackson and Ambrose, 1976, 44).

[2] In addition, slots probably existed in the piers, as a loose block found near pier 4 has the same feature. If so, a parallel might be found in the piers at the Römerbrücke in Trier (Bidwell and Holbrook, 1989, 112).

Excavations (Scott, 1982, 77) have shown that the original line of Dere Street running across Tofts Field northwards from the first bridge was re-surfaced ca 180, and that this surface was inferior to the re-surfacing of ca 130. This suggests that this section of Dere Street ceased to be part of the main military route north, and by ca 180, served only the civilian settlement. This theory is supported by the fact that this section of the road was later encroached upon by the settlement associated with the 3rd century fort (Bidwell and Holbrook, 1989, 110). As this section of Dere Street, continuing north from the first bridge, had most likely fallen out of use as the main military road by the 3rd century, the first bridge must also have ceased carrying the trunk road over the Tees by the same period.

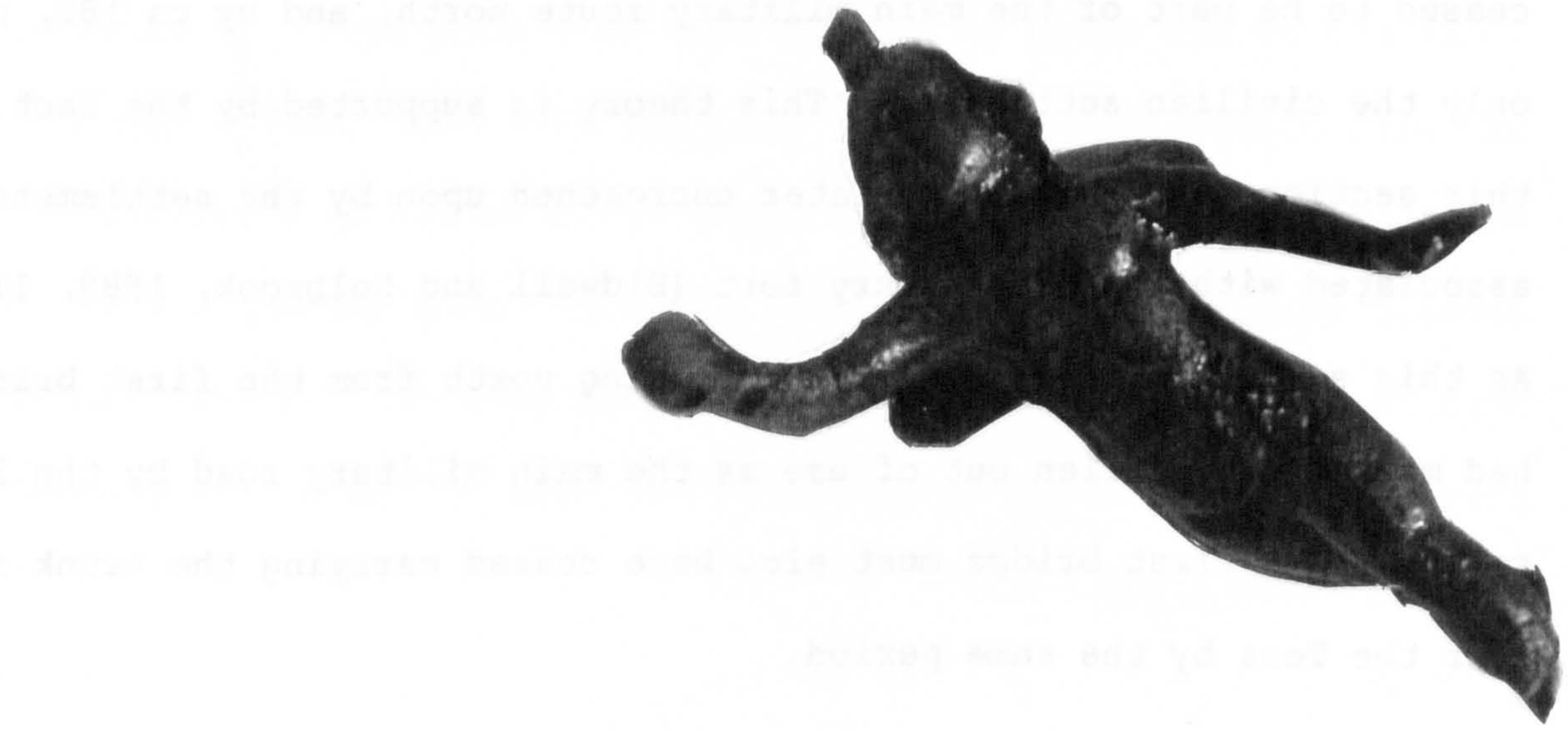
In addition, evidence attests to a re-alignment of Dere Street to cross the Tees over the 'second' bridge. This line was found during the digging of a sewage trench in a field at Holme House on the south bank, and again in Carlbury Vale on the north bank of the Tees (Scott, 1982, 79). Although no dating evidence was found during excavations of the second bridge, its construction may have been associated with the settlement at Holme House, which perhaps accommodated workers constructing the bridge (Scott, 1982, 79).[1] The settlement, and by association perhaps the second bridge, has been dated by pottery to AD

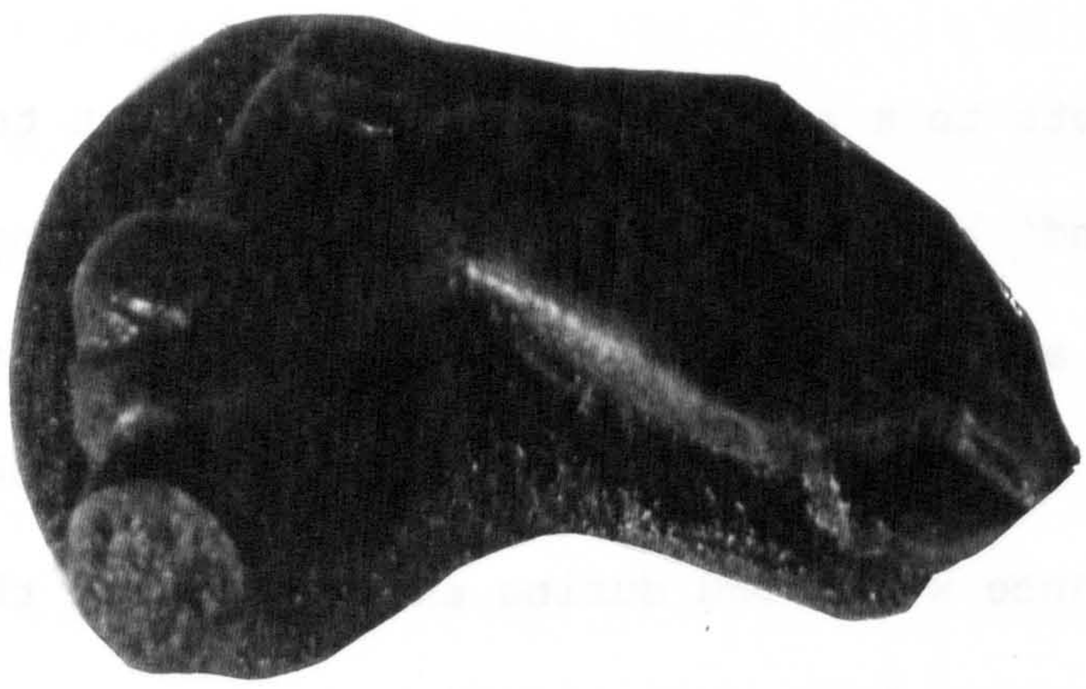
---

[1] This site lies 915m south-east of the point where Dere Street crosses the Tees, and dates to the 2nd century (Harding, 1970). It consists of a stone rectangular house of three rooms, with elaborate bath-suite, as well as a later wing and possibly a Trajanic period round-house.

Plate: 9

Artefacts found in the River Tees near the first Roman bridge, at Piercebridge, County Durham. The photographs were taken from cast copies, loaned by R. Selkirk.





0 10cm

130-180 (ibid.).

The second bridge has been considered a 'dam' because artefacts found under the first bridge proves not only its use as a bridge for the whole Roman period, but also the redundancy of a second bridge at the 'dam site'. However, the context of this evidence is suspect, and the find spots may not be indicative of where the artefacts originally were deposited: it is possible that artefacts from the banks on either side have been redeposited along the breadth of the river, and 'trapped' by the ruins of the bridge on the river bed.

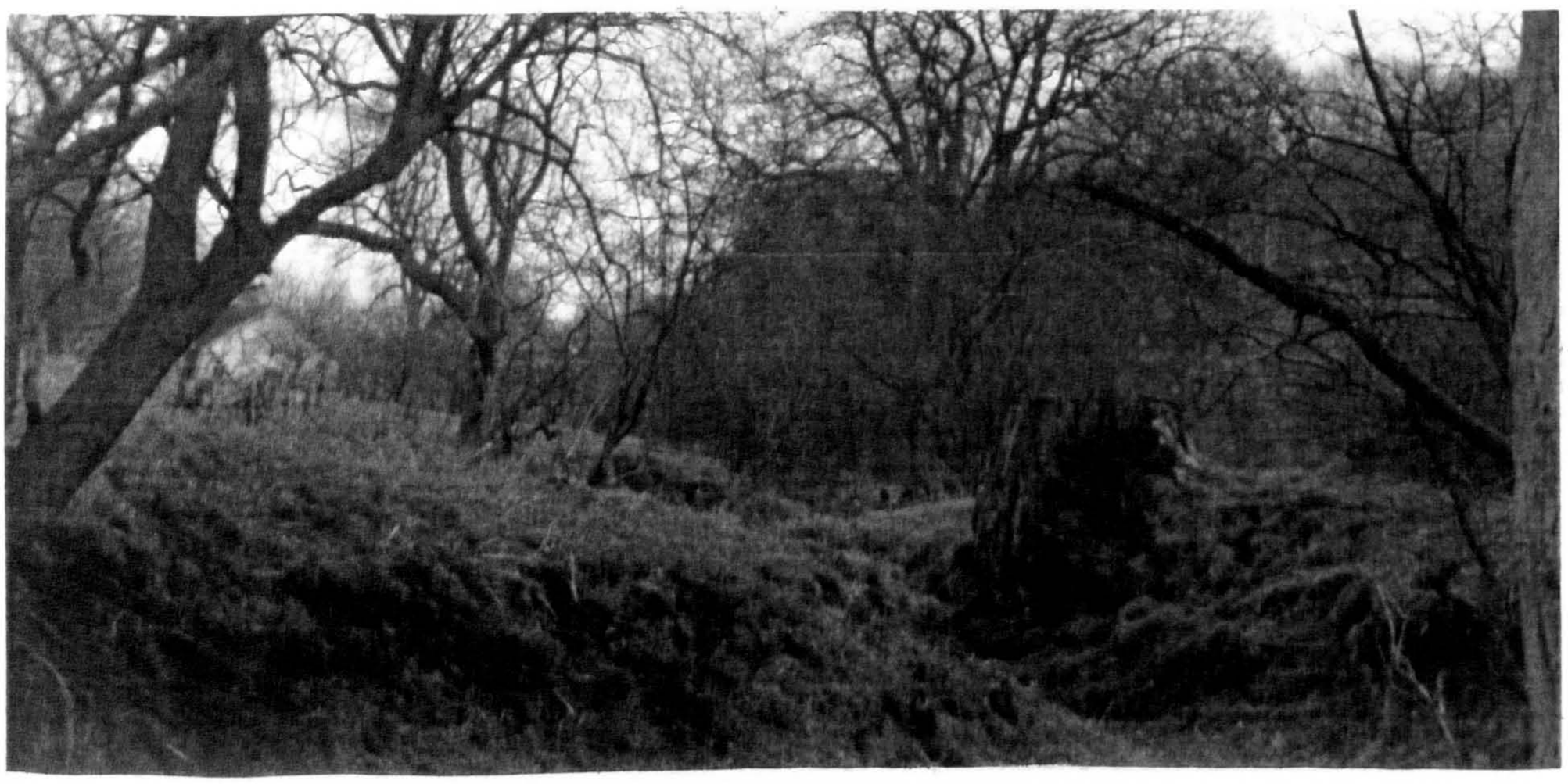
Indeed, and as discussed, the Tees moved laterally during the Roman period and has continued to do so. Before the regulating dam and reservoir were constructed upriver at Cow Green just after World War 2, the Tees was subject to very rapid flooding after heavy rain (ibid., 77), so that both banks of the river in the vicinity changed rapidly from one year to the next (Kitson Clarke, 1934, 386; Scott, 1982, 77, 80). Indeed, during the 1960's part of the cliff on the south bank above the present bridge collapsed and was washed downstream until it formed a large extension to the south bank of the river below the George Hotel, having the effect of forcing the river northward and threatening to wash away the north bank below Tofts field (Scott, 1982, 80). Thus, similar processes could have washed material from the river banks and deposited it between the piles (Bidwell and Holbrook, 1989, 110) at any time from the Roman period to the present.

However, while such processes may account for the deposition of ceramics and other artefacts, the high recovery rate of silver coins and artefacts such as figurines is curious. As for the coins, it is possible that other coins have not been recovered, and that the silver coins represent a much smaller proportion of the total amount of coins deposited. However, on present evidence, the high proportion of silver coins, as well as figurines, suggests indeed that these may have been 'offerings' thrown from the side of the bridge.

Yet again, the deposition of such artefacts need not be inconsistent with a bridge which had ceased to function as a crossing for wheeled traffic: indeed, the bridge may not have been completely ruined. Situated as it was at the bottom of a 'chute', this bridge may have required constant maintenance after flood damage, and it may have been this necessary maintenance, rather than the total destruction of the first bridge, which spurred construction of a second bridge at a less vulnerable position further downriver. Although the first bridge soon may have become unusable by wheeled traffic, it may have continued to be safe enough for pedestrians. Therefore, the deposition of artefacts below the bridge may perhaps be explained as soldiers and/or civilians propitiating their gods, and perhaps specifically the river god of the flood-prone Tees, from what had become the village 'foot-bridge'.

Plate **10** 'Barge Harbour', Piercebridge.

'Barge Harbour', Piercebridge, 'S'-bend.



'Barge Harbour', Piercebridge, 'S'-bend.

Barge-harbour

Certain conspicuous features of the 'barge-harbour' give rise to suspicions about the accuracy of its identification in The Piercebridge Formula. In addition to its deep descent, it passes through an obvious 'S'-bend at the half-way point (see plate 10). Both of these features seem inconsistent and contrary to what might be expected from a barge harbour: the aim surely would have been to create as wide and straight a channel as possible. However, the gradient of the channel would have been sufficient to push a mill of the undershot type (Coupland, 1987, 46).

Barge wharves

Finally, it seems that the 'barge wharves' can be explained in the context of a Medieval mill. They were probably relief or by-pass channels which the miller used for the diversion of excess water down the race (ibid.).

3.1.3 Conclusion

Evidence suggests that the structures at Piercebridge are contrary to what has been described in The Piercebridge Formula and associated articles. The 'by-pass canal' must be considered in the overall geo-fluvial context of the river Tees and the Dyance Beck. A pound-lock on its bottom courses would have aggravated the problem of flooding in

the fort and Roman period settlement, while the 'barge passing-place' is likely a former course of the Beck before this meander was by-passed with the cutting of the channel. Conversely, the channel's gradient renders the 'upper pound-lock' superfluous, and the channel is in some places very narrow for the passage of barges. Because none of these features would have affected adversely, and in fact would have benefited a mill site at the bottom of the channel, it is likely that the channel was constructed from the first as a mill-race. This context would also account for the different character of masonry in its sluices, compared to the masonry of the second bridge across the river.

The sometimes steep gradients and 'S'-bend in the upstream channel argue against a 'barge harbour' with 'wharves'. Again, this channel fits better into a mill context.

The 'dam' at Piercebridge is rather the second of two Roman period bridges. The excavated remains of the structure conform well with a bridge, and dating evidence suggests construction in the late 2nd century. Dating evidence also suggests that after the first bridge had gone out of use, Dere Street was diverted to the second bridge, at which point its original course was abandoned. Conversely, artefactual material spanning the Roman period does not preclude the existence of a second bridge. The artefacts could have been released from the banks and distributed among the ruined bridge piers by river action, or thrown by pedestrians from the bridge after it had ceased to function as a crossing for wheeled traffic.

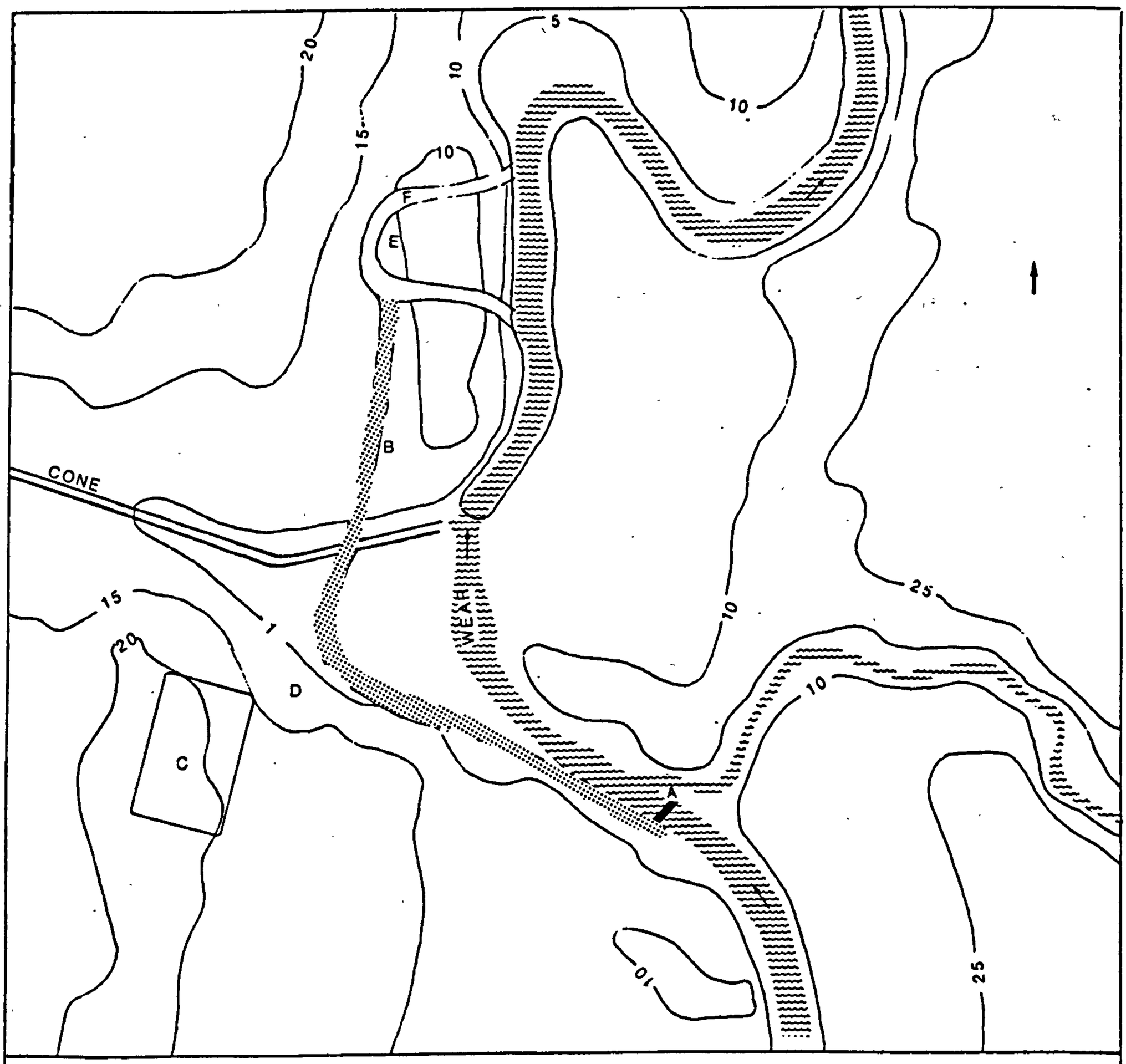


Fig 6: Chester-le-Street

A ROMAN DAM ?

B ROMAN CANAL ?

C FORT

D ROMAN BARGE HARBOUR ?

E REMAINS OF STONE PIER (1856 OS)

F FORMER RIVER COURSE

0 500m 1:10,000

J/91

3.2 CHESTER-LE-STREET

Chester-le-Street lies along the Wear, the next major river north of Piercebridge. Thought to be Roman Concangis,[1] the fort was constructed along a Roman road running parallel to and east of Dere Street, and near a road branching south-westerly and joining Dere Street a short distance north of Binchester (see figure 2). Chester-le-Street fort lies upon a rise south-west of the confluence of the rivers Wear and Cone, 22km from the mouth of the Wear. Until recently, the first fort was thought to belong to the early 3rd century on the basis of an inscription dated 216 (RIB 1049, discussed below). However, two phases of the fort have been identified during recent excavations, the first of which may have been Antonine (Bishop, 1991, 8).[2] This earlier fort was of turf and timber construction, consisting of a west-facing ditch and rampart on a north-south alignment (ibid.). According to the Piercebridge formula (Selkirk, 1983, 72-9), Chester-le-Street Roman fort was supplied by river barges navigated from the Wear's mouth upriver to the fort through a system of three dams equipped with locks, and a by-pass canal/barge harbour below the fort.

---

[1] It is generally associated with the Concangios in the Notitia and Conganges in the Ravenna list. Rivet and Smith (1979, 314) suggest Concangis, meaning 'horse-people'.
[2] A BB2 rim sherd was recovered within the sandy turve layer (the lower level is composed of clay blocks) of the west rampart of the earlier fort, suggesting construction in the first half of the 2nd century (Bishop, 1991).

3.2.1 Evidence Supporting the Piercebridge formula

Dams

Three Roman period dams facilitated shipment by barge of supplies from Wearmouth to Chester-le-Street (Selkirk, 1983, 77). The first, demolished in the early 19th century,[1] was near Hylton, 6.4km from the sea. On the basis of accounts of the structure made before its demolition, Reverend Featherstonehaugh, in a meeting of the Sunderland Antiquaries Society, ca 1895 (from Selkirk, 1983, 77; see figure 8), described a causeway or dam:

> "[it was] a causeway of solid stone masonry extending across the river, and raised some feet above its bed. It had formed a substantial dam, over which, at ebb tide, the water fell in a considerable cascade... the masonry was said to be broken between the centre and the northern shore, and the stones were of massive size, of regular shape and tied with iron cramps bedded in lead. These stones were laid on oaken piles driven into the bed of the river, and on the lower side and outside the structure, stood piles of greater height. There was also a good deal of horizontally laid timber with mortised joints between the piles."

In addition, the oblique angle at which the structure crossed the river would have reduced the depth of water spilling over the top, and prevented boats being swept across accidentally (Selkirk, 1983).

Finally, minutes of another meeting of the same society convening

---

[1] This is imprecise: the structure was dismantled in 1865 (PSAN 1.19, 1884, 131-8).

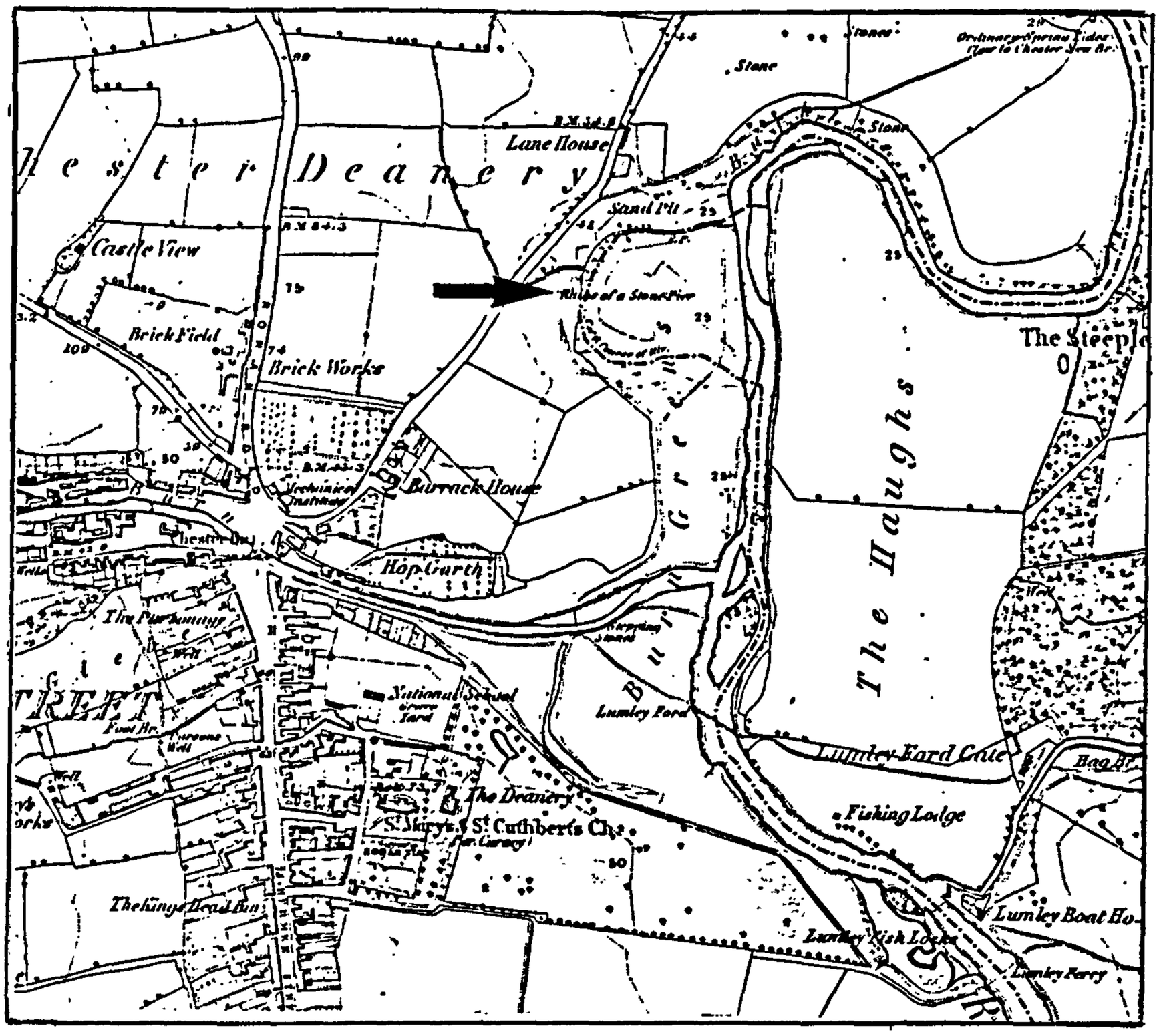


Fig 7: Chester-le-Street: OS map first edition, 1856, showing 'ruins of a stone pier' in a former course of the Wear.

Fig 8: RIB 1049, attesting to a territorium at Chester-le-Street (Collingwood and Wright, 1965; 349).

. . .] *eq(uitum)* | [*alae* . . .Antoni]nianae | . . . *t]erri-to*|[*rium* . . . *aquam*] *induxit* | [*balneum* . . . *a s]olo in*|[*struxit sub cura* . . .]*diani leg(ati)* | *Aug(usti) pr(o) pr(aetore) Sabin(o) II et An]ullin(o) co(n)s(ulibus)*

'. . . of the troopers of the Cavalry Regiment . . . *Antoniniana* . . . domain-land . . . brought in a water-supply, and erected a bath-building from ground-level under the charge of . . ., emperor's propraetorian legate, in the consulship of Sabinus for the second time and of Anullinus.'

In the restoration adopted here it is assumed that a complementary slab carried the full names and titles of the emperor Caracalla, expressed in the nominative as subject to *induxit* and *instruxit*. For a slab carrying only half the text see *RIB* 1914 (Birdoswald). For a comparable inscription to Caracalla see *RIB* 1279 (High Rochester).

1, 2. . . . GENIO N(VMERI)] EQQ | [. . . ANTONINIANORVM] Hoopp.; EQ(VITES) | [. . . *ANTONINIANI*] F. H.; . . . (about 15 letters lost)] EQQ | [ALAE . . . *ANTONI*]*NIANAE* R. P. W., conj. [VTILITATI ET VSVI] EQQ, cf. *CIL* v 7250 (*ILS* 5701) Segusio, *CIL* viii 18328 (*ILS* 5520) Lambaesis.

3–6. . . . PR · EQQ · NATIONE BIG]ERRIT(ANVS) Q|[VI AQVAM IN STATIONEM I]NDVXIT | [ET . . . A S]OLO IN|[STRVXIT Hoopp., conj. in l. 5 BALNEVM CVM BASILICA; IN BALNEA (?) T]ERRIT(ORIVM)Q(VE) | [EORVM F. H. quoting Momm.; . . . (about 17 letters lost) T]ERRITO|[RIVM . . . (about 9 letters lost) AQVAM] INDVXIT | [BALNEVM . . . (about 12 letters lost) A S]OLO · IN|[STRVXIT R. P. W., conj. in l. 4 DEFINIVIT *or* LIMITAVIT *or* TERMINAVIT, in l. 5 CVM BASILICA.

6, 7. SVB CVRA . . . (about 7 letters lost)]DIANI LEG | [AVG PR · PR · SABIN · II · ET AN]VLLIN · C(O)S Hoopp., Watk. Hooppell and Birley (in Askew *Coinage* 82) restore M . ANT . GOR]DIANI.

7. A.D. 216, the consuls were P. Catius Sabinus II and P. Cornelius Anullinus.

about 1910 (Selkirk, 1983)[1] include a discussion of a circular metal plate with inscriptions reading IM D A G...AUG around the margin, and S C or S G, the 'D' of which refers to Domitian (PSAN 1.19, 1884, 134). In addition, many stones were found which had finely-cut decorations of columns, vine leaves, and castellations, all of which suggests Roman work (Selkirk, 1983).

The second 'dam' lies north-east of the fort, and would have ponded-up not only the River Wear, but also a 'by-pass' canal incorporating a 'barge harbour' under the fort (ibid., 73). This 'dam' is represented on the OS first edition (1856) as 'ruins of a stone pier', within a feature described as a 'former course of the river' (see figure 7 and 6:E). These remains must represent a dam, because of the unlikelihood of a bridge structure at this site (Selkirk, 1983, 73). First, the position of the structure suggests that it may have "extended across the ancient river bed at right angles", consistent with a dam structure. Second, a dedication stone found in 1930 near this pier suggests a dam rather than bridge (ibid, 77). This dedication refers to a "prefect" at Chester-le-Street who brought "water to the fortress": by virtue of its position on or near the stone structure, it must refer to "navigation" water (ibid.).

---

[1] Again this is imprecise: the meeting covering the lead plate found at Hylton was in fact convened by the Society of Antiquaries of Newcastle, in 1884, not Sunderland in 1910.

The third dam, located east of the fort on the River Wear, just below the point at which the 'by-pass' canal veers west from the Wear towards the fort, is identified as such by its construction (Selkirk, 1983, 79; see figure 6: A). During modern work on this structure, "squared stones with typical Roman feathered toolmarks", as well as "typical Roman masonry" were excavated from its foundations (Selkirk, 1983, 79). Further, as the structure "sloped 45 degrees", it appeared to be "one side of an old spillway of a dam", rather than a bridge abutment (ibid.).

Locks

The first dam at Hylton was equipped with a pound-lock (Selkirk, 1983, 78). At the second meeting mentioned above (PSAN 1.19, 1884), attention was drawn to 'breakstones' around the stone structure, which had been described in the early 19th century: clearly visible at low water, the stones apparently formed a steep channel 4-4.3m wide. Within this channel a Roman pound-lock once existed (Selkirk, 1983, 78).

'By-pass Canal' and 'Barge Harbour'

Dam III would have ponded-up the Wear sufficiently to feed a 'by-pass' canal curving west from the river to the fort and north to enter the Wear at Dam II (see figure 6: B). Below the fort, the channel would have widened, so that barges moving either up or down the canal could have put into a 'harbour' (see figure 6: D).

3.2.2 Evidence Refuting the Piercebridge formula

Dam I

Both the construction and dateable material of the dam at Hylton is questionable. Unfortunately, the demolition of the structure precludes its positive identification as a causeway, dam, or bridge. Even so, the antiquarians themselves were divided in their assessment. Indeed, locals who had seen the structure before its destruction argued that it was a bridge (PSAN 1.19, 1884): Mr Lister witnessed hundredweights of lead, an oak frame beneath, and moulded, decorated and wedge-like stones pulled from the river, all of which suggested a bridge. In addition, Hooppell argued that "the banks of the river were very high between where the stones were, and ran out into the river exactly like abutments [of a bridge]", while Mr Longstaffe suggested a Roman road may have crossed somewhere in this area (ibid.). Dymond has summed-up (1963, 156) this legacy of conflicting antiquarian accounts by describing the structure as a bridge, paved ford, or combination of the two.

As for the position of the structure, its oblique angle across the river (Selkirk, 1983, 77) does not prove a causeway or navigation dam. As discussed above (1.1), the character of rivers in the North-east, particularly the often violent flooding throughout the channels' courses, as well as the often high sediment concentrations within the rivers themselves in times past, have created numerous meanders throughout the rivers' courses. Because of the lower sediment concentrations today, the

rivers have become narrower and have incised, leaving extinct meanders or palaeo-channels. The transient nature of these river channels makes it likely that over a long period of time, the Wear would have moved significantly across its bed at any given point along its course. Therefore, the Wear at the Hylton structure may have moved since the period of its construction, at which time the structure may have been oriented ninety degrees to the Wear's course.

As for the suggested Roman date of this structure, the evidence of the lead plate is dubious. Indeed, Hooppell's identification was based on a drawing of the plate, as the original had long been lost (PSAN 1.19, 1884). In any event, this plate and the stone into which it was set was probably recovered in a secondary context. Indeed, stones from post-Roman periods were identified at the site by antiquarians:

> "...one of the stones was apparently Medieval, and some apparently Roman, and some apparently Saxon."
>
> Longstaffe in PSAN 1.19, 1884, 137

Therefore, it is likely that this structure was built with stones robbed from various contexts at some time in the post-Roman period.

In addition, a Roman period date of this structure, whether dam or bridge, is rendered unlikely because of the lack of a known Roman road approaching either side of the structure. According to the Piercebridge formula, a dam requires a road onto which supplies could be unloaded from barges moving along the river. Supplies would then be trans-shipped to ox-carts for transport overland. However, Mr Longstaffe's Roman road

branching east of Concangis (PSAN 1.19, 1884) has never been located, and the apparent lack of a Roman period road near this structure is therefore conspicuous. Similarly, a Roman bridge without a road is superfluous (Coupland, 1987, 17).

On the other hand, the nature of this structure is rather more suggestive of a Medieval fish-works context. First, as discussed, the Medieval terminus post quem of some of the stone found within suggests a Medieval date. Second, the lack of a road to service the fish-works is unproblematic, and its close proximity to the sea advantageous. Third, the robust character of this structure is consistent with a fishing dam at this site: it would have to be constructed to withstand the annual floods, as well as the daily ebb and flow of the Wear's tide.[1] Finally, many precedents exist elsewhere in the North-east for Medieval fish-works. Indeed, the Rivers Wear, Tees, and Tyne possessed extensive commercial fisheries which flourished throughout and beyond the Medieval period to about the mid-19th century.[2] Most of these fisheries consisted of weirs simply obstructing the passage of fish to their spawning grounds upstream. The fish[3] were caught with nets either below the dams or along side streams (Binnie, 1987, 16).

---

[1] Indeed, the tidal limit of the Wear today is just below Chester-le-Street, and well above Hylton.

[2] The Wear, Tees, and Tyne had become so polluted by heavy industry in the estuaries, water carriage sewage systems, lead working in the upper courses and small coal washeries in the middle reaches that fishing had all but died out by the mid-19th century (Kirby, 1969, 125).

[3] These consisted of small brown trout, as well as migratory trout and salmon.

In short, the dateable material, position, and construction of this structure, as well as the fact that such fisheries were so common along these rivers, together suggest a Medieval to post-Medieval period fishery at Hylton, rather than a Piercebridge formula dam.

Dam II

If the 'pier' described on the 1856 OS map (see figure 7) does in fact represent a structure crossing the Wear at right angles in the Roman period, this orientation is also consistent with a bridge. Although the lack of a nearby Roman road[1] renders a road bridge unlikely, this 'pier' may have belonged to an aqueduct bridge. The clue resides within RIB 1049, the accepted translation of which is as follows (see figure 8):

> " ...] eq(uitum) [alae... Antoni]nianae ...t]errito[rium... aquam] induxit [balneum ... a s]olo in[struxit sub cura...]diani leg(ati) Aug(usti) pr(o) pr(aetore) Sabin(o) II et An]ullin(o) co(n)s(ulibus)"
>
> "...of the troopers of the Cavalry Regiment... Antoniniana... domain-land...brought in a water-supply, and erected a bath-building from ground level under the charge of..., emperor's propraetorian legate, in the consulship of Sabinus for the second time and of Anullinus"
>
> RIB 1049, from Collingwood and Wright, 1965, 349

Mention of the cavalry unit stationed at Chester-le-Street, with its name

---

[1] The Roman road running north through Chester-le-Street towards the Wreckendike passes west of the area described as a former course of the Wear (see figure 7), and no other Roman road has been found running close to this structure.

purposefully deleted in the second line,[1] is followed by mention of the territorium, provision of a water-supply, and finally what has been construed as the building of a bath-house, during the consulship of Sabinus and Anullinus and the reign of Caracalla, in 216.

The arguments suggesting that the provision of a water supply refers to an aqueduct are two-fold. First, the relevant word in this inscription - induxit - is also used to describe the conveyance of water by aqueduct to the fort at South Shields on an inscription dated to 222 (RIB 1060, Collingwood and Wright, 1965). Rather than conducting 'navigation water', both inscriptions are likely to represent a general policy throughout the North-east in the first quarter of the 3rd century and after the retreat from the Severan period advance into Scotland, of construction which focussed on fort renovation and amenities such as aqueducts (Wright, 1940b, 90). Second, an aqueduct at Chester-le-Street may have been necessary for provision of water to the fort bath-house. Although olo in is rather liberally interpreted (Collingwood and Wright, 1965, 349) as the 'erection of bath-house from the ground level', archaeological evidence suggests a bath-house south of the fort. Indeed, such a building was described in 1856 as a hypocausted "villa" (Bruce, 1856, 121-2).

---

[1] Since the names of the consuls dates this inscription to the reign of Caracalla, this unit may have borne the title Antoniniana in the emperor's honour, in which case it may have been erased along with other inscription's bearing Caracalla's name after his death (Wright, 1944, 84). However, the name Antoniniana does not refer, as has been suggested (Selkirk, 1983, 77), to the prefect of Chester-le-Street.

Dam III

The argument for a Piercebridge formula dam at the Lumley fish-locks hinges on the stone and general character of the structure fitting a Roman period context.

However, antiquarian accounts suggest that the stones noted by Selkirk belong to a late 18th century dam, rather than to a Roman period structure. After the 1771 flood destroyed much of the dam at the site, the engineer John Smeaton was asked to inspect the remains. From Smeaton's description, it appears that this dam could not have possessed the stones recently described as "squared... with typical Roman feathered tool marks" (Selkirk, 1983, 79).

> "On viewing ... the dam at Lumley I find its original construction ... unsafe...it surprises me how it has stood for so long... the top is composed of stones of a very middling size, they are kept down by laying a beard of brushwood upon them, which is kept down by laying stone thereupon, when this fails the walls of the dam is like to be taken down."
>
> Smeaton, ca 1776

Not only are no Roman period stones mentioned, the overall description of the dam contrasts with the known Roman dam at Lanchester, which, as described above (2.1.1), is a structure significantly more solid: it has a core of clay rather than brushwood and stones, and is faced on both sides with masonry.

Rather, the recently excavated stones are likely to belong to a post-1771 reconstruction of the Lumley dam. Smeaton (ca 1776) advised

driving oak piles 2.5ft (.75m) below the surface of the pond, 10 ft (3m) upstream from the dam front:

> "... I propose long stones 8" or 9" [20cm] thick (if more the better)... not less than 3ft [.9m] [long]... stamped [together] and to long deep setters [on the front]. [This front] should be supported by an apron upon piles driven into the pond downstream."

Upon this advice, only that part of the dam which had been destroyed was repaired accordingly. However, a later flood[1] demolished the remaining part of the dam which had not been repaired, so that in 1795, the dam underwent complete reconstruction (Lumley, MSS EMC/6/17, from Kirby, 1969, 129). This included raising the structure from .7-1.8m, building it entirely of stone, and removing completely the heather and brushwood of the previous dam. In this reconstruction the long stones recommended by Smeaton were used throughout. It is also these stones which are referred to in The Piercebridge Formula (Selkirk, 1983, 79) as being dredged recently from the Wear, and which are identified as Roman.

As for the pre-1771 dam, it appears that this structure fits a Medieval context. A fishery immediately below Lumley Castle is first mentioned in the Boldon Book dated 1183 (Kirby, 1969, 125). Still pools were set in a low sandy haugh left of the river in order to attract the fish, which were caught either with drag nets and boats, or driven-up the Lumley Park Burn (ibid.).

---

[1] This flood may have been that of 1795, which is recorded as rising along the River Tees 7 or 8 inches [17.5-20cm] higher than the Great Flood of 1771 (Sykes, 1833).

Locks

The 'lock' in the Hylton structure also can be explained in the context of a fishery. The flood-prone Wear seems to have had the simplest of fish-traps:

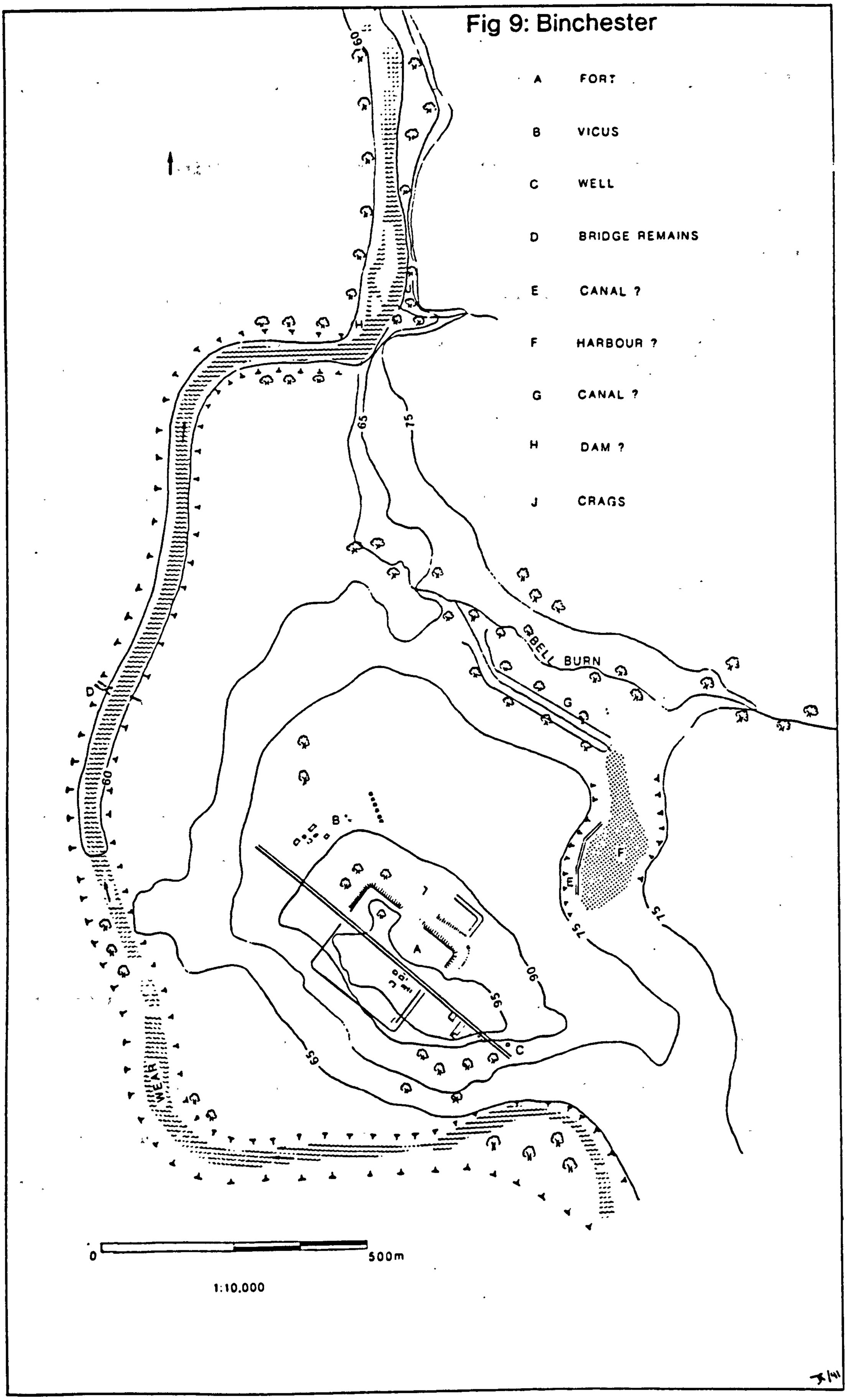
> "Although the purpose was only to catch fish the simple expedient of erecting grills across gaps in weirs was not adopted for these fast rivers because the great quantities of ice, trees and debris brought down by them in times of flood would have destroyed such traps... [so that] many traps were set in gaps in weirs".
>
> Binnie, 1987, 16

Therefore, given the proliferation of Medieval fish-works along the Wear, these gaps more likely would have been constructed and used in the first place for catching fish, rather than for facilitating the passage of barges.

By-pass Canal

Rather than a 'by-pass canal', this feature can be described as the furthest extent to which the Wear scoured its left bank during some previous period of overbank flooding or westerly meander. Given the likelihood that the Wear in the Roman period was silt-prone, slow, and apt to meander, it is possible that the Wear followed such a meander in the Roman period. If so, it would explain the choice of this site for the fort. Indeed, the bend in the Wear, together with the Cone burn to the north, would have surrounded on three sides the heights upon which the fort was constructed, while at the same time this position would have

Fig 9: Binchester



facilitated the protection by the garrison of the bridge carrying Dere Street over the Wear.

3.2.3 Conclusion

No archaeological evidence of Roman period river navigation exists at Chester-le-Street. In the absence of evidence proving a Roman period context, the 'dam' and 'lock' at Hylton, as well as 'Dam III' below the fort are more likely to represent Medieval fisheries. If indeed a Roman period structure, the second 'dam' is more likely to be the remains of an aqueduct bridge constructed across the remains of a bend in the River Wear, and the 'by-pass canal' a fossil of the Wear's meandering past.

3.3 BINCHESTER

Binchester fort, referred to as Vinovia in the Antonine Itinerary,[1] is situated 35km along the River Wear above Chester-le-Street, about 16km north of Piercebridge and 50km south of Corbridge along Dere Street. It was constructed during the Flavian period upon a plateau which overlooks to the west the Wear crossing of Dere Street. It is argued in The Piercebridge Formula (Selkirk, 1983, 79-81) that supplies were barged from the mouth of the Wear to this fort: after negotiating the Wear to a dam below Binchester, barges would have been brought up the Bell Burn and

---

[1] In addition, an inscription (RIB 1036) records the dedication of an altar by a soldier: EX C(UNEO) VINOVIE(NSIUM), and is referred to as Vinovium in Ptolemy's Geography, and Vinonia in the Ravenna list.

two canals to a harbour situated in a valley below and to the north-east of the fort (see figure 9).

3.3.1 Evidence Supporting the Piercebridge formula

The large swampy area in a valley north-east of the fort was once a barge harbour, as it is both "the right size and certainly in the right place" (Selkirk, 1983, 81; see figure 9: F).

Along the west aspect of the barge harbour is evidence for the first part of a barge canal, which "consisted of straight lengths and, as the natural depression curved, the water channel altered course with precise angles in a typical Roman manner" (ibid., 79). This canal henceforth will be referred to as Channel I (see figure 9: E).

Following a projected course of Channel I beyond the 'harbour' is "a very long, straight stretch of canal which headed back towards the River Wear downstream from Vinovia" (Selkirk, 1983, 81; see figure 9: G), henceforth referred to as Channel II. Mounds running parallel and to either side of this channel would have restricted flood waters to the channel course, while the space between mounds and channel provided a towpath: the channels, together with the Bell Burn and Wear, surrounded the fort with water (ibid).

Masonry located at NZ 209 325 along the River Wear just north of the confluence of the Bell Burn belongs to a Roman 'dam' (see figure 9: H),

Plate: 11 The 'barge harbour' below Binchester Roman fort, south facing north. Sample cored from upper left in photo, or north-east area of swamp.

Plate: 12 Sample cored from 'barge harbour', at a depth of ca.2m below surface. Traces of charcoal used for radio-carbon dating indicated.

which would have directed water into the Bell Burn, and from there into two channels to the barge harbour north and east of the fort: "If this masonry were intact across the river, the dry canal would flood to a depth of about 7 ft [2.1m] at the Roman fort - just right" (Selkirk, 1983, 81).

3.3.2 Evidence Refuting the Piercebridge formula

Barge Harbour

The swampy area regarded as a 'barge harbour' forms a natural basin at the bottom of steep hills to the west, south and east. Given its position, the swamp would have been a natural water collection point throughout the millennia. Although today the area is under water only for brief periods during the winter months, modern water works have greatly reduced the water table in the vicinity.[1] As no evidence for Roman harbour works exists on the ground today, alternative methods were sought to determine the nature of this swamp and surrounding hillsides in the Roman period. After some preliminary probing, it was determined that at least 2.5m of soft sediment lay beneath the swamp bed, a depth sufficient to allow a geo-morphological analysis.

---

[1] At Vinovium Cottage, just north of the Bell Burn, a British Coal station pumps about 50,400,000 gallons (229,068,000 litres) per week into the lower half of Bell Burn (Coupland, 1987).

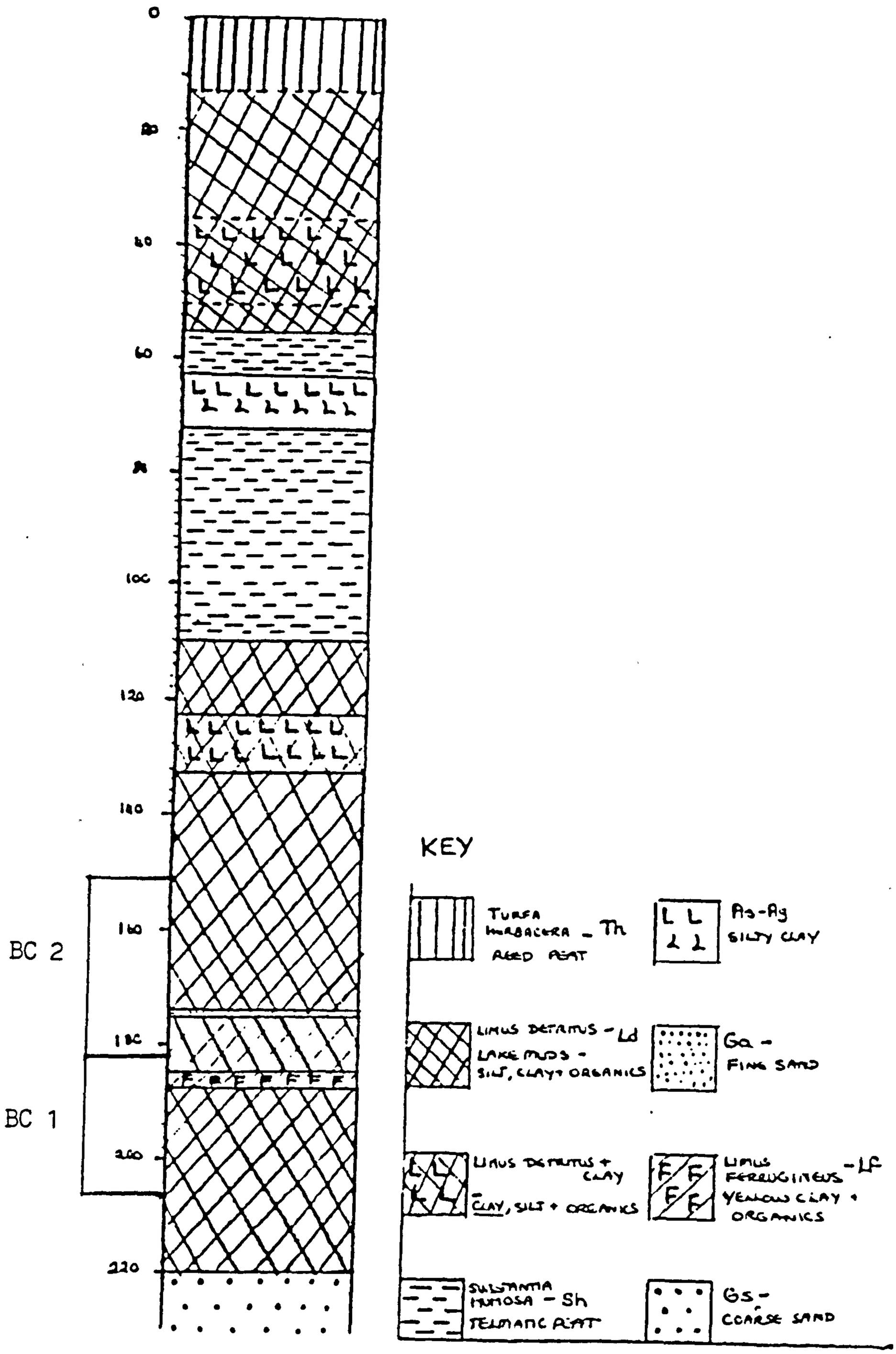


Fig 10: Stratigraphy of core at Binchester, showing BC1 and BC2, from Cummins, 1991.

Geo-morphology at Binchester. On May 16, 1990, and in conjunction with the Department of Geography, Newcastle University, five 5cm sections (cores) of sediment 2.2m deep were extracted using a 'Russian'-type corer from the deepest point of the valley bottom, ca 70m OD. After transport to the lab, one core was examined[1] in terms of stratigraphy, carbon, pollen and trace metals content.

After a stratigraphic analysis of the core's silts, clays, peats, organics, and colour and texture of the sediments, five distinct 'phases' within the core were identified. Although many variables prevent the layers of sediment from representing a precise linear time-scale, the stratigraphy nevertheless provides a guideline to the chronological sequence of events taking place in and around this swamp. Of the five phases, the first two (which are also the bottom and earliest phases) are the most relevant to this thesis (see figure 10, plate 12). Located 2.06-1.82m below the surface, BC-1 comprises first a layer of coarse grey sand, perhaps representing a substantial inwash. This gives way to silt, clay and organics, comprising black and highly-humidified 'lake' muds, followed by a period of limus ferrugineus (1.87-1.83m) where precipitated iron oxides or sulphides have turned yellow on oxidation. BC-2, located at 1.81-1.52m, includes a small incursion of brown fine sand between two heavy layers of lake muds.

---

[1] This research was undertaken in large part by Ms G Cummins for the partial fulfillment of a BA dissertation. All data, as well as a full interpretation of the analysis can be found in Cummins, G, 1991.

Charcoal recovered within the core material was used, among other things, to obtain a date for BC-1. This phase, and therefore the bottom of the core, was dated to 2075 +/- 55 BP (Beta 41570/ETH 7550), or BC 125 +/- 55, very close to the Conquest period of the North-east.[1]

Although BC-2 was not dated by the radio-carbon method, a strong possibility exists that it too belongs to the Roman period. First, precedence from elsewhere (discussed above, 2.1.2) suggests that after forested lands had been cleared, a period of pastoralism often gave way to intense agriculture in the Roman period, and the overall conclusion of this analysis reflects this trend (Cummins, 1991). Second, many things suggest that BC-3 begins with the Viking invasion, and a period of re-forestation. The cereal pollen count declines with an increase in tree pollen. Elsewhere, re-forestation begins at about this time at Bolton Fell (AD 780 +/-50; Barber, 1981), and AD 595 +/-50 at Hallowell Moss. Therefore, it appears that BC-1 and BC-2 stretch across the Roman period occupation of Binchester.

---

[1] All radio-carbon dates in this thesis will be described first in terms of years BP (calibrated), or the number of years before AD 1950, and the parameters in years within which the specimen might be dated before and after the specific radio-carbon date. Second, the radio-carbon date code registered with the firm Beta Analytic, Coral Gables, Florida is given. Third, the date will be given in terms of years AD, followed by the wider possible dating parameters. In addition, all samples in this thesis were radio-carbon dated by the same process (by the firm mentioned above). All were pre-treated by first examining for rootlets, and then given a hot acid wash to eliminate carbonates. They were then repeatedly rinsed to neutrality and subsequently given a hot alkali soaking to remove humic acids. After rinsing to neutrality, another acid wash followed and another rinsing to neutrality. A benzene synthesis and count followed.

Given these rough dating parameters, an examination of the results of the BC-1 and BC-2 analysis is important in terms of land use and water volume within the swamp and in the vicinity.

1. Land use of the valley which drains into the swamp can be assessed primarily with an examination of the pollen analysis results. Samples 1cm cubed were taken every 5cm along BC-1, and after preparation,[1] the pollen component was counted.[2] Thereafter, five different pollen sums were used to present the data.

BC-1 is represented by Gramineae (grass), Alnus (alder), Cyperaceae (sedge), and Pteridium (fern). Gramineae is the dominant taxa throughout, averaging for most of the core about 90 per cent of the total tree and herb pollen. It later drops to about 70 per cent as first Cyperaceae then Pteridium and Alnus peak. Although there is a slight presence of cereals at 1.98m, it is unlikely to be more than a small percentage of the surrounding land-use, and could quite possibly be a wild grass. Very little evidence exists for trees throughout BC-1. Even when Alnus peaks at 18 per cent at 1.90-1.91m, this is probably due to the relative decline of Gramineae caused by local changes. Apart from Alnus, evidence for trees is negligible.

---

[1] After minerogenic content was removed by hydroflouric acid, and four lycopodium tablets were added to each known weight of sediment, the samples were mounted in glycerine jelly, and stained with safarin pigment.

[2] Counting was undertaken using phase contrast microscopy, under x400 magnification, with an average 150-200 grains counted on 24 slides.

The almost total absence of trees at the bottom of the core suggests an earlier period of clearance. This agrees with Turner's conclusion (1979) that deforestation took place on an extensive scale ca BC 100 - AD 200. After the clearance, the valley sides and bottom around the swamp became covered in vegetation. It is likely that the vegetation on the slopes surrounding the lake did not change, except for a gradual increase in Pteridium in the open landscape. In total, anthropogenic indicators in BC-1 are of pastoral and disturbance types.

BC-2 is represented by Gramineae, Quercus (oak) and Cerealia. The latter become increasingly significant, producing a real decline in Pteridium and Gramineae. These indicate both pastoral and arable land use, or mixed farming. However, the decidedly lower Gramineae values reflect land-use change to predominantly arable cultivation. Oak values decrease, perhaps suggesting continued clearance for cultivation, and in total, it is virtually a treeless habitat.

That cultivation increased during BC-2 is supported also by the charcoal, trace metal, and sediment analyses. The charcoal indicates catchment firing, perhaps to improve the fertility of the soil prior to planting (Vuorela, 1986). As for trace metals, between 1.87-1.85m, the iron and manganese levels reflect an episode where iron compounds have been precipitated into the lake muds. This is most likely due to an inwash of organic liquids and excessively fast accumulations of

sediments, such as might be expected during high levels of cultivation.[1] Similarly, a small peak in the calcium concentration associated with this level was also probably derived from organic inwash resulting from agricultural disturbance. Finally, an influx of brown sand at 1.75-76mis probably caused by an increase in erosion after burning and destabilizing of the landscape. Erosion increases sharply through BC-2, starting at the change to arable, and peaking at 1.55m.

In total, it seems that shortly before the Roman arrival at Binchester, the area had begun to be cleared. After major deforestation and consequent erosion, the swamp's catchment began to be covered in grasses, with trees left only in certain areas and perhaps around the rim of the swamp. The pastures gradually began to give way to arable fields throughout BC-2. Given this high level of agriculture, unlike today, the hills surrounding this swamp would have been very vulnerable to erosion and colluvial run-off. Given that the swamp forms a natural basin at the bottom of three steep hills, this sediment would have been washed into the swamp.

2. Water Levels. Pollen analysis has shown the gradual increase and large quantity of Sparganium in BC-1 through BC-2. As a rule, the greater the encroachment of this aquatic species, which grows only around the edges of the swamp and never underwater, the greater the degree of

---

[1] Diluted calcium, iron and manganese leached out by redox conditions have combined with it because of preferential complexing (Cummins, 1991).

water recession within the swamp. Therefore, throughout the Roman period, the quantity of water within and therefore the size of the swamp was decreasing.[1]

This may have been due to the lower levels of precipitation in the general warm period, which, as discussed above (2.1.2), spanned the Roman period in Britain. As this dry period reduced the level of water in river systems, so too would it have affected the water tables. The water table also would have been affected by the propensity for Roman soldiers to use large amounts of water. Indeed, the bath-house of phase VIb of the fort as well as an earlier (probably Flavian) bath-house 60m outside the south-east rampart of the fort suggests a high degree of water consumption. That such water supplies were acquired from a local source is suggested by two things. First, the fort is at the apex of a hill: an aqueduct system feeding the baths with water from a distant source would have required an aqueduct bridge, for which there is no evidence, or a very elaborate and long system of siphons, evidence for which is almost negligible across the entire Empire (see Anderson, J D, 1987). Second, a Roman well was located by Hooppell (1891, 22) ca 200m south-east of the fort and to the side of Dere Street, proving at least one local water source.

---

[1] However, traces of Potamogeton, an underwater plant species, were found at 1.87-1.85m, suggesting a certain degree of standing water at least in the middle of the swamp.

Plate: 13 Channel I at Binchester. South facing North; pole at max. depth.

Plate: 14 Channel II. East facing West; Rig and furrow field beyond to west.

Channel I

The first channel, 2.5m wide and 2m deep (maximum)[1] and lying along the western edge of the 'barge harbour', can be interpreted rather as a drainage channel (see plate 11). First, the channel is much deeper than the 'barge harbour'. Indeed, if indeed a barge canal beside a harbour, it is difficult to see why the canal would have been cut so much deeper than the harbour itself. If cutting this canal was necessary for barge passage, it is curious why similar cutting was not necessary across the 'barge harbour'.

Second, the channel is set at the bottom of a very steep, high hill, on the west side of the 'barge harbour', or swamp. As discussed, this swamp is a natural basin and water collection point, and before the British Coal pumping (see note above), it would have contained standing water. This channel then, running north towards Channel II, the Bell Burn, and eventually the Wear, seems specifically designed to drain the swamp of excess water running into it from hills to the east, south and west.

Given the lower amounts of precipitation and water table in the Roman period, it is unlikely that a channel to drain the swamp would have been necessary during the Roman period. Therefore, a later period context seems likely. The hills on the east, south and west of the swamp are

---

[1] In May, 1990, the channel contained water to a depth of 1.5m.

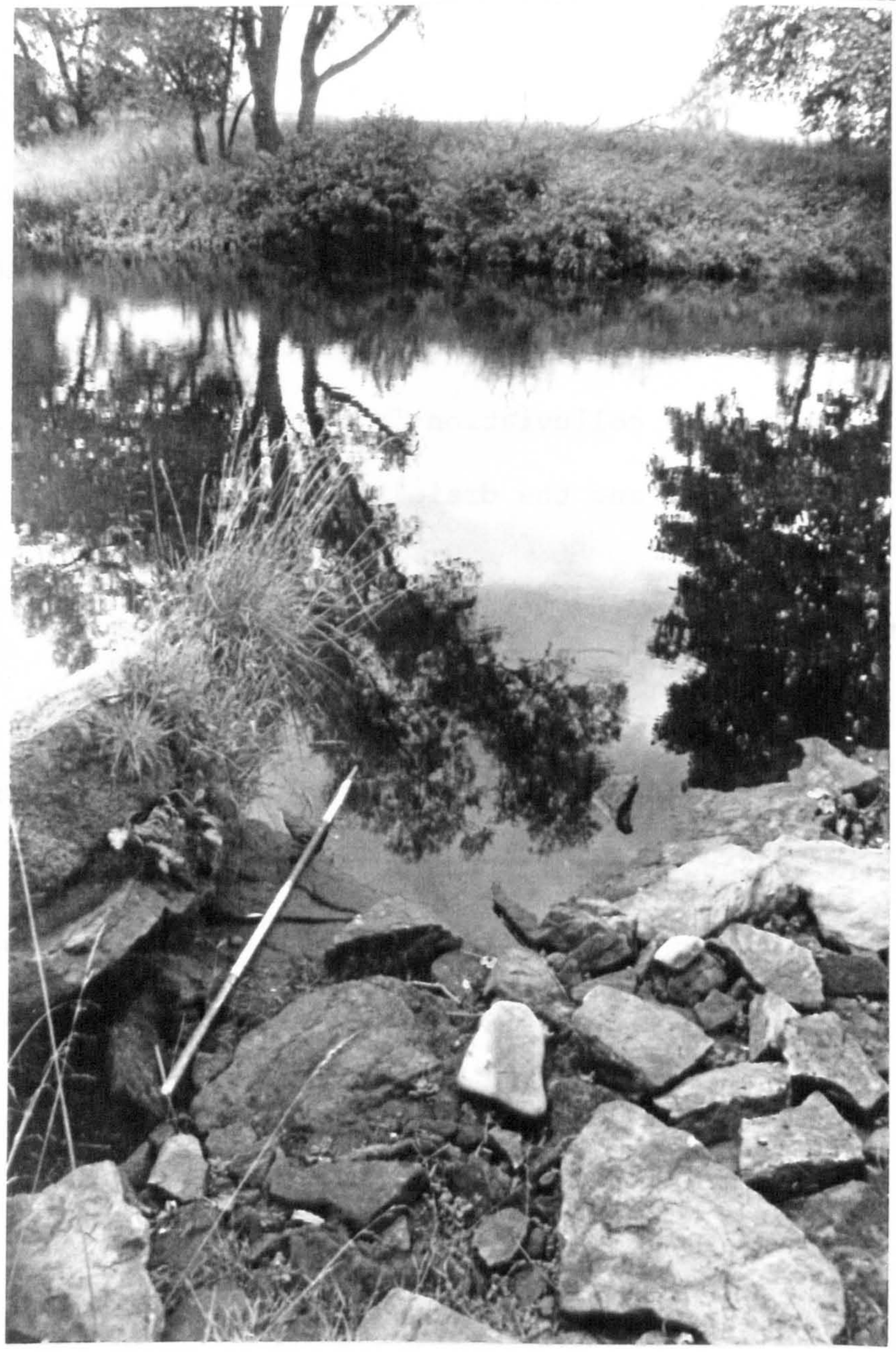
covered by broad rig and furrow plough marks of the 13th-14th centuries. Such vertical rather than horizontal terraced ploughing would have increased colluviation into the swamp. This period of potentially higher rates of colluviation is a likely candidate for the cutting of the channel, and the draining of the swamp.

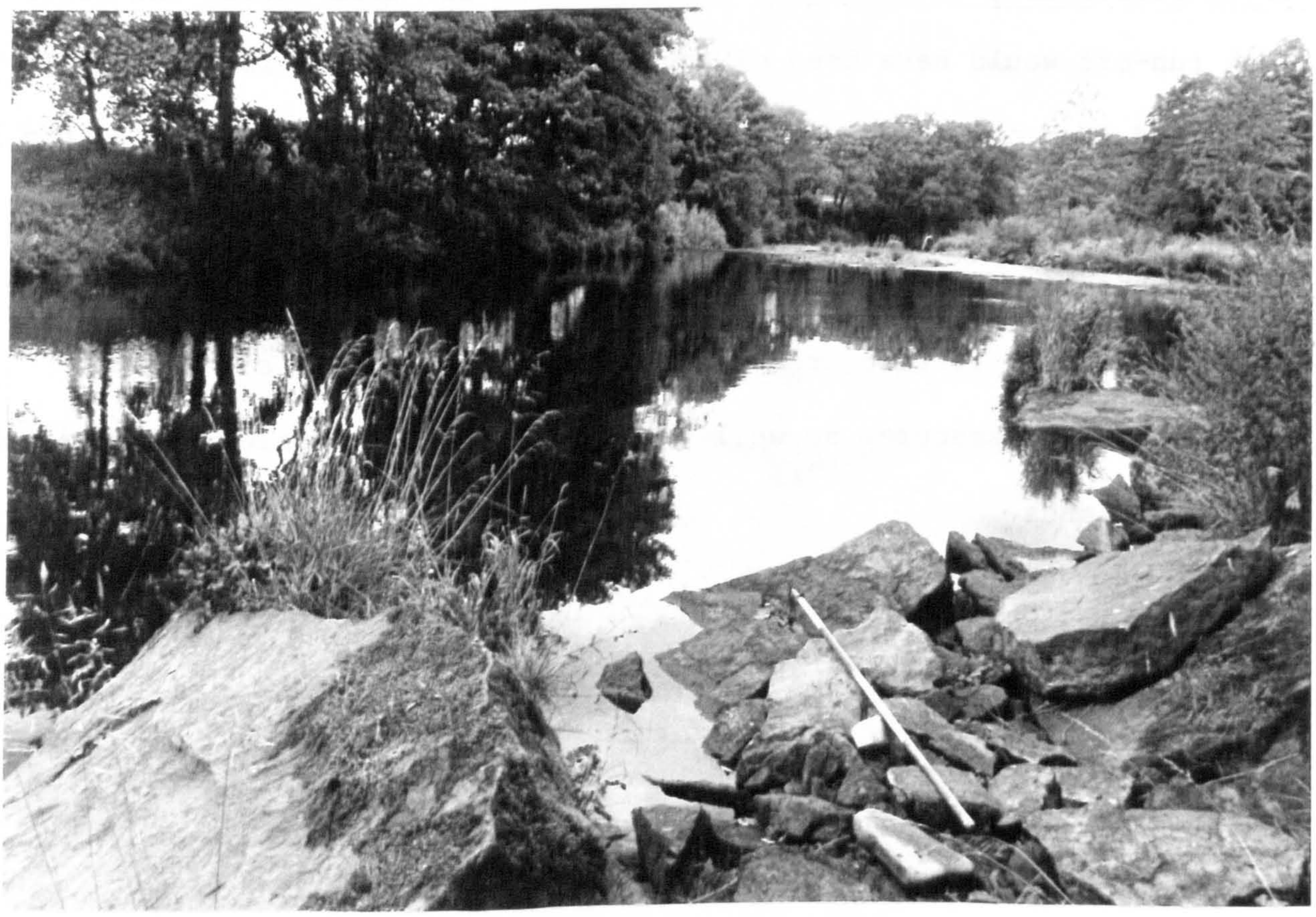
Channel II

The second channel begins at the extreme north end of the swampy area, or the 'barge harbour'. It is generally 'V'-shaped, straight, and runs north-westerly for 350m until it bends sharply north and into the Bell Burn (NZ214317 to NZ211320). The channel varies in width, averages 3m at the top, and as with Channel I, likely functions as a drainage channel (see plate 13).

Its position at the lowest point of the swamp would have allowed it to drain efficiently colluviation from hills to the east, west, and south. Such run-off would have been directed down this channel into the Bell Burn, and from there into the Wear. Although such an elaborate system is probably unnecessary today due to the drop in water table, before this century such a system would have efficiently drained this area, thereby freeing the most fertile areas at the bottom of the hills for both agriculture and pasture, as well as guarding against diseases associated with swamplands.

Plate: 15 Stone in River
Wear below Binchester Crags.





Same as above; south facing north.

As for the ca 1m high and 2.5m wide mounds forming parallel lines ca 4m on either side of Channel II, these may indeed have prevented overbank flooding from within the channel as has been argued (Selkirk, 1983, 81). However, this is perhaps more of a corollary function. The mounds are placed not only on either side of the channel, but also at the bottom of the rig and furrow fields running perpendicular to the mounds. It is likely that these mounds represent in the first place earth from the excavated channel, and in the second boundaries at the bottom of rig and furrow fields.

Dam

Rather than 'old masonry', many large slabs of rock and boulders were found at the site of the 'dam' (see plate 15). These rocks have slid down the right bank through natural processes of erosion from a face referred to as 'Binchester Crag',[1] located at NZ 2099 3255, and on the river's right (east) bank. Indeed, nothing common to Roman water works is in evidence on the site, such as finely-cut ashlar, opera quadrata, lewis-holes, iron cramps or holes, and nothing about the remains recalls the known Roman dam at Lanchester. Rather than Roman masons, nature has worked and moved these stones into their present shapes and positions.

Furthermore, the site lies at 60m compared to the 'barge-harbour' at 70m, 1.5km distant (Coupland, 1987). In order to overcome this 10m

---

[1] OS: NZ 23 SW, 1:10,000, 1973.

discrepancy, four Piercebridge formula dams would have been necessary. These dams are not mentioned in The Piercebridge Formula, and after close inspection beginning from the 'harbour' through Channels I and II, and down the Bell Burn to the Wear, no masonry of any description was found, let alone of the Roman period.

3.3.3 Conclusion

No archaeological evidence for Roman navigation exists at Binchester. The 'barge harbour' and 'by-pass canal' rather comprise a comprehensive drainage system for run-off from the sloping fields in the area, while there is nothing to suggest a Roman dam in the Wear.

CHAPTER FOUR

EVIDENCE: AREA 2

Descending northwards from the Pennine Spurs of Area 1, Dere Street crosses into Area 2 over the River Tyne at Corbridge. The Roman site is at the junction of Dere Street, which continues north to cross the Wall into Area 3 at Portgate, and the Stanegate running east-west. Although the route of the Stanegate is uncertain east of Corbridge (discussed below, 6.2.1), its course west of the North Tyne can be traced to Carlisle.

Three rivers traverse Area 2. The South Tyne and North Tyne converge into the Tyne at Hexham, and the Tyne, running west to east, eventually flows into the sea at South Shields.

The Hadrianic Wall system was constructed north of, and parallel to the Stanegate west of Dere Street, and the River Tyne east of Dere Street. This system consists in Area 2 of a stone curtain of varying widths and heights running ca 70km from Wallsend to Carvoran. After following the north bank of the Tyne in the east until it crosses the North Tyne at Chesters, the Wall continues westwards along the northern edge of a natural outcropping known as the Whin Sill. Milecastles (fortified gates) and turrets (watchtowers) were constructed along the Wall every Roman mile (ca 1500m) and 1\3 Roman mile (ca 500m), respectively, and a 'V'-shaped ditch was cut north of the curtain. While

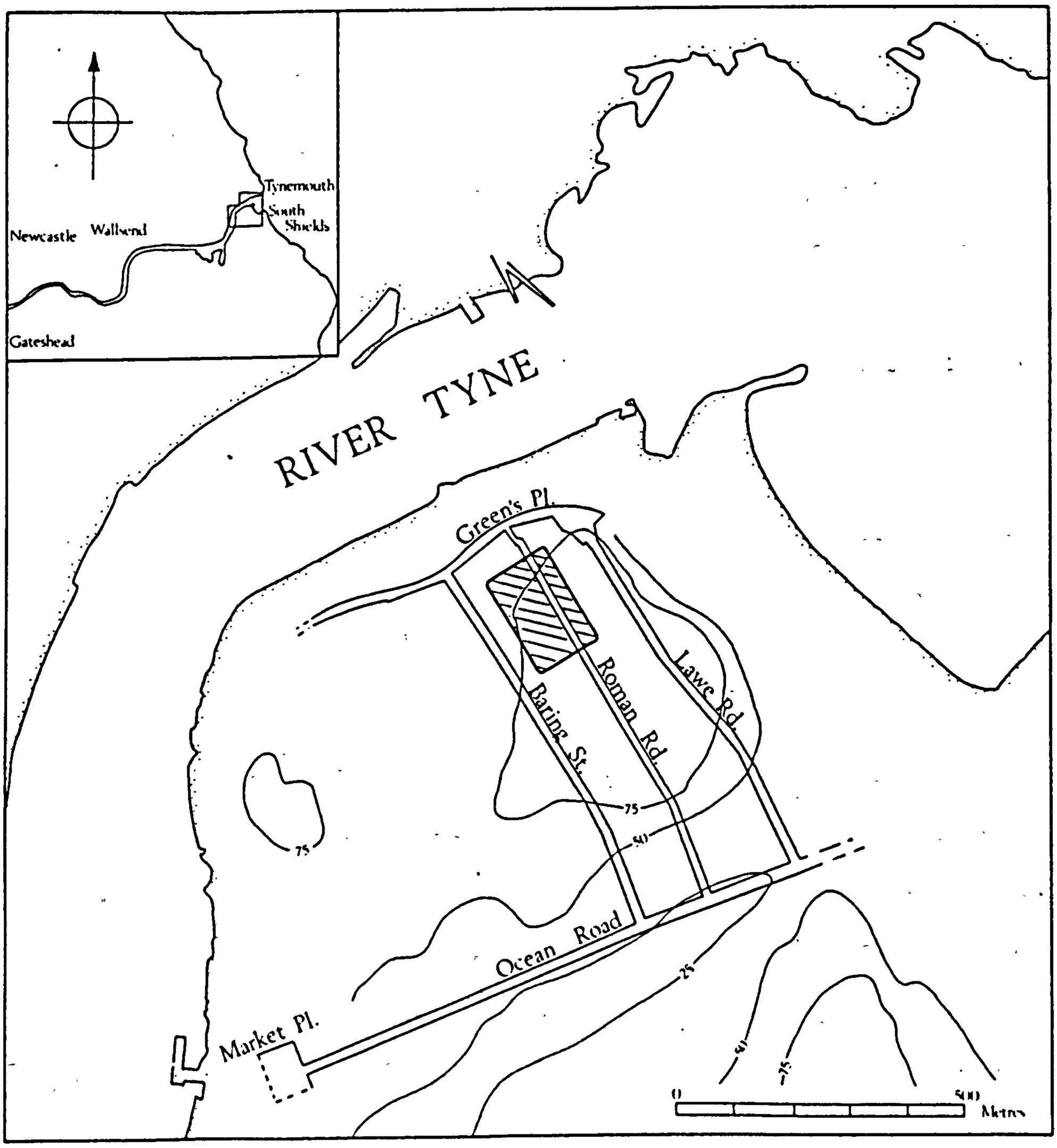


Fig 11: The location of South Shields Roman Fort, from Dore and Gillam, 1979.

Corbridge and Vindolanda remained behind the Wall line, ten forts were eventually constructed within the Wall curtain at intervals of ca 6 Roman miles (9km), each occupied intermittently to the end of the Roman period. Although varying in size and other characteristics, these Wall forts share remarkable structural homogeneity. Eventually the vallum and Military Way were constructed behind the Wall line.

The sites examined within Area 2 include South Shields, Bywell, Corbridge, and Vindolanda.

4.1 SOUTH SHIELDS

South Shields fort, commanding the heights overlooking the mouth of the river Tyne, is thought to be the Arbeia of the Notitia Dignitatum (Anon, Occ xl 22).[1] According to the Piercebridge formula, after ships had sailed into the Tyne, supplies would have been unloaded for storage in the supply depot at South Shields. Afterwards, a unit of barcarii stationed at the fort (Selkirk, 1983, 99):

> "... would tow the barges up the Tyne, dropping off supplies at Wallsend, Newcastle-upon-Tyne, Benwell, Rudchester (with a short cart journey) and Corbridge. They could have turned into the North Tyne to supply Chesters, and then into the Rede to supply Risingham, Blakehope and High Rochester."

---

[1] That Arbeia is South Shields is also suggested by the following: a tombstone has been recovered near the site with an inscription (RIB 1065) written both in Latin and Aramaic (Bates, 1898, 152), the site is referred to in the post-Roman period as Caer Urfa, a reasonable development of Arbeia, and a unit stationed there is thought to be from the area along the Tigris known as Bet Arbaye (Kennedy, 1986; discussed below).

South Shields, then, holds a pivotal position in the Piercebridge formula between sea-borne supply and river transportation carried out by a special unit of bargemen. Both issues will now be explored, with particular attention paid to the first. Indeed, determining whether South Shields functioned as a supply base throughout the Roman period is not only necessary in an examination of the Piercebridge formula, but is fundamental to the general question of supply to forts in the North-east, which is addressed below in Chapter 6. As the discussion of the supply base, which is dealt with under 'Evidence Supporting the Piercebridge formula', represents also the views of the author of this thesis, it will not be included under 'Evidence Refuting the Piercebridge formula'.

4.1.1 Evidence Supporting the Piercebridge formula

South Shields as a 'Supply Base'

Excavation throughout the 1980's has thrown much light on the position of South Shields as a supply base receiving supplies for forts in the North-east throughout the Roman period. The following relies heavily upon recent site reports, the latest of which is as yet to be published (Bidwell and Speak, forthcoming).

Pre-Antonine period. That the site of the later stone forts was involved somehow as a sea port from the Flavian period is suggested by evidence of Flavian and later occupation somewhere either east or south of the later mid-Antonine stone fort.[1] In support of this, its position overlooking the point at which the Tyne discharges into the sea suggests that any Conquest period occupation of this site would have been involved to some extent with port duties. Furthermore, Agricola's advance into northern Scotland, and probably along this coast is recorded as being in close contact with the Classis Britannica (Tacitus, Agric 25.1; discussed below, 6.1.3).

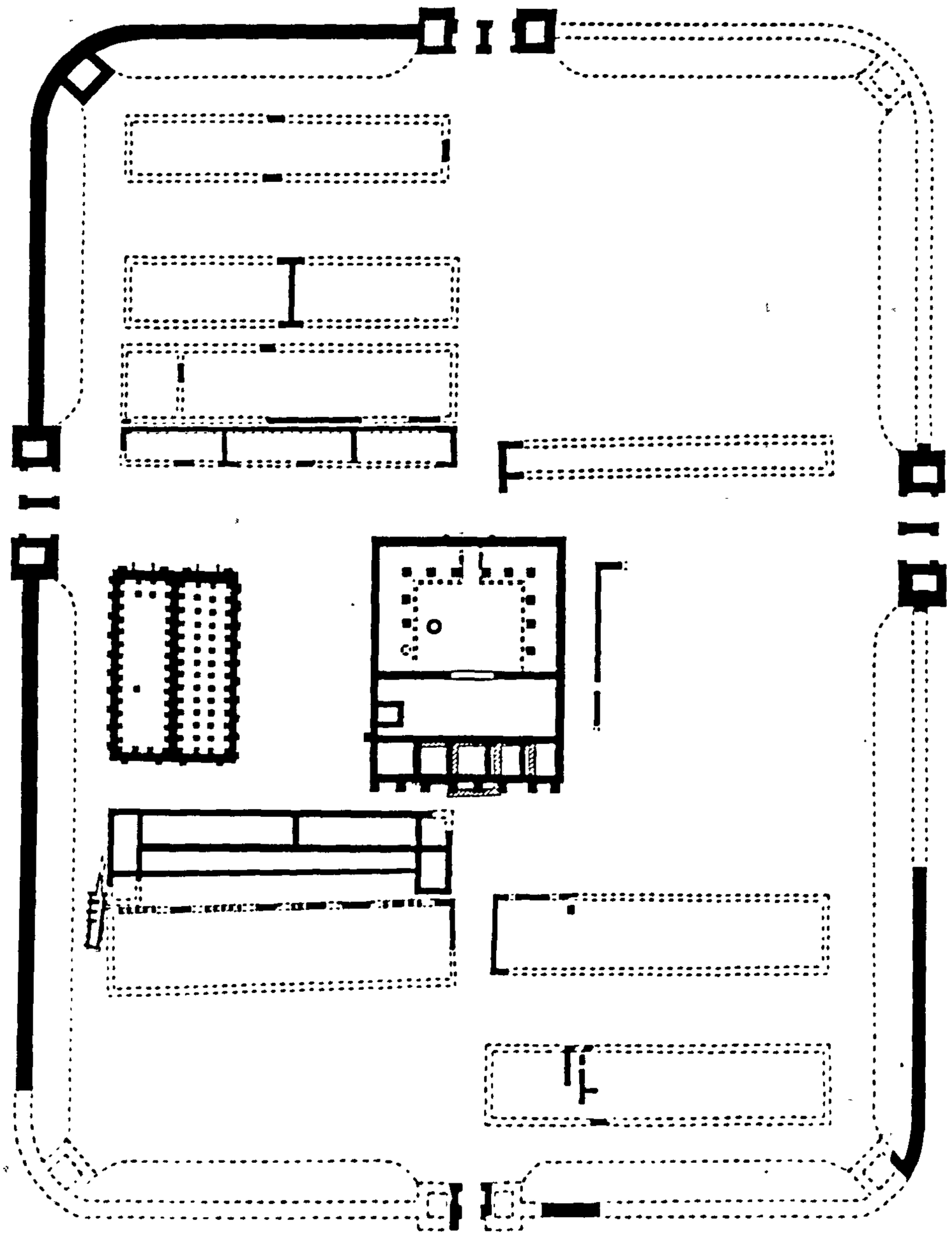
Although evidence (discussed below, 6.1.2) suggests that up to the mid-Antonine period BB1 and therefore other material was supplied to the Wall forts from the west coast, it is likely that at least some materials were supplied to at least the eastern Wall forts from ships sailing into the Tyne. Indeed, the Tyne was the natural point of entry to the eastern aspect of the northern frontier, and South Shields would have been by far the closest and easiest port from which these forts could be supplied.

---

[1] This includes pottery such as terra nigra, Pompeiian Red Ware, early amphorae, and La Graufesenque samian, as well as coinage from Nero (Casey in Dore and Gillam, 1979, 76), and an unprecedentedly large collection of early brooches (Bidwell and Speak, forthcoming, 10).

Fig 12: Period 4 Antonine fort at South Shields,

from Bidwell and Speak, forthcoming.



Antonine period. With the Antonine re-occupation of Hadrian's Wall, a marked shift takes place in BB ware distribution on the northern frontier (discussed below, 6.1.2) from a western to an eastern bias, suggesting very strongly that from the mid-Antonine period the forts in the North-east were supplied to a large extent from South Shields. Such a shift may be marked by a new stone fort on the site, which has been dated by samian and other pottery to the mid-Antonine period (Bidwell and Speak, forthcoming, 24; see figure 12).

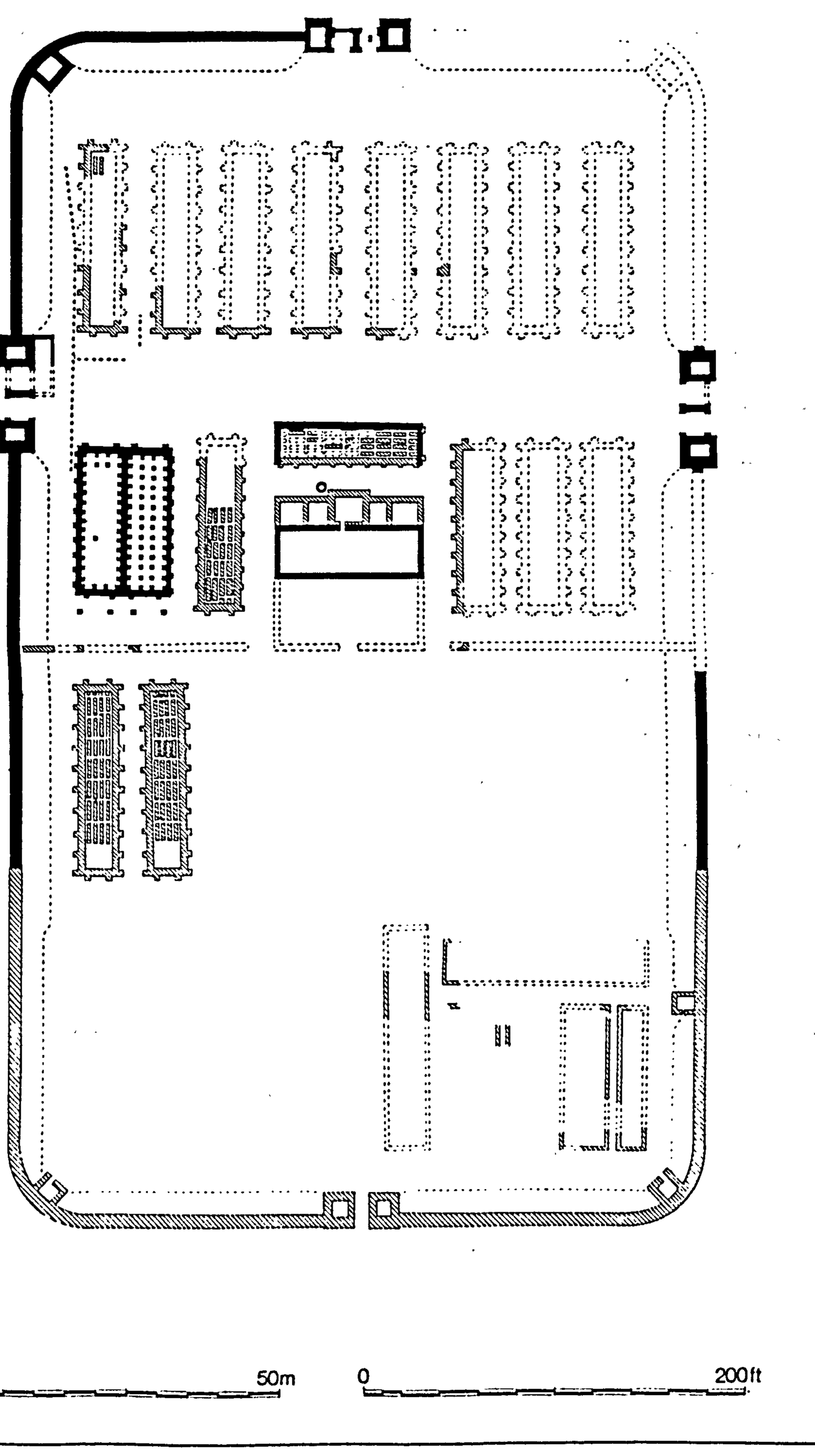
The fact that the many granaries of the Severan period fort have not been found in earlier contexts[1] does not rule out this site functioning as a port for sea-borne supplies. Supplies aboard ships putting into the port may have been simply 'trans-shipped' without being stored at the fort (Salway, 1965, 62-3). However, it is more likely that some sort of storage facilities existed: the often poor climate at South Shields near the North Sea coast would have meant that certain cargoes (especially grain) would have to be trans-shipped quickly or stored somewhere dry in order to prevent spoilage, and it is unlikely that a 'fleet' of ox-carts would have been waiting at South Shields to haul away an entire ship's cargo immediately after it had sailed into port. Such storage facilities may have been situated extra-murally (pers comm P T Bidwell), and either have not been recovered or have perished through intense urban

---

[1] Indeed, the first and second stone forts (Periods 4 and 5) had only one double granary (building A5: Dore and Gillam, 1979, 29-32; 36), which would have held grain supplies sufficient only for the soldiers garrisoned at South Shields.

Fig 13: Period 5 Severan fort at South Shields,

from Bidwell and Speak, forthcoming.



development over the centuries. The capacity of such facilities may have been more modest than that of the 3rd century intra-mural granaries: indeed, as will be discussed (Appendix H-3; below, 6.2.3), many of the army's demands, including grain, may have been supplied on a local level during this period rather than by sea from long distances away.

Severan: Period 5. Pottery[1] as well as evidence from lead seals,[2] attests to construction of many granaries within the Severan period fort (see figure 13). The fort was extended on the south-east to accommodate the granaries, and a dividing wall was constructed across the fort's interior. In addition to the original double granaries which were kept in use, thirteen granaries were constructed to the north, and two to the south of this wall, making seventeen in total. The granaries were constructed with ten buttresses along each side, and were composed of the same material.[3]

In the context of the Piercebridge formula, were these granaries constructed to hold grain for North-eastern forts? It is possible that

---

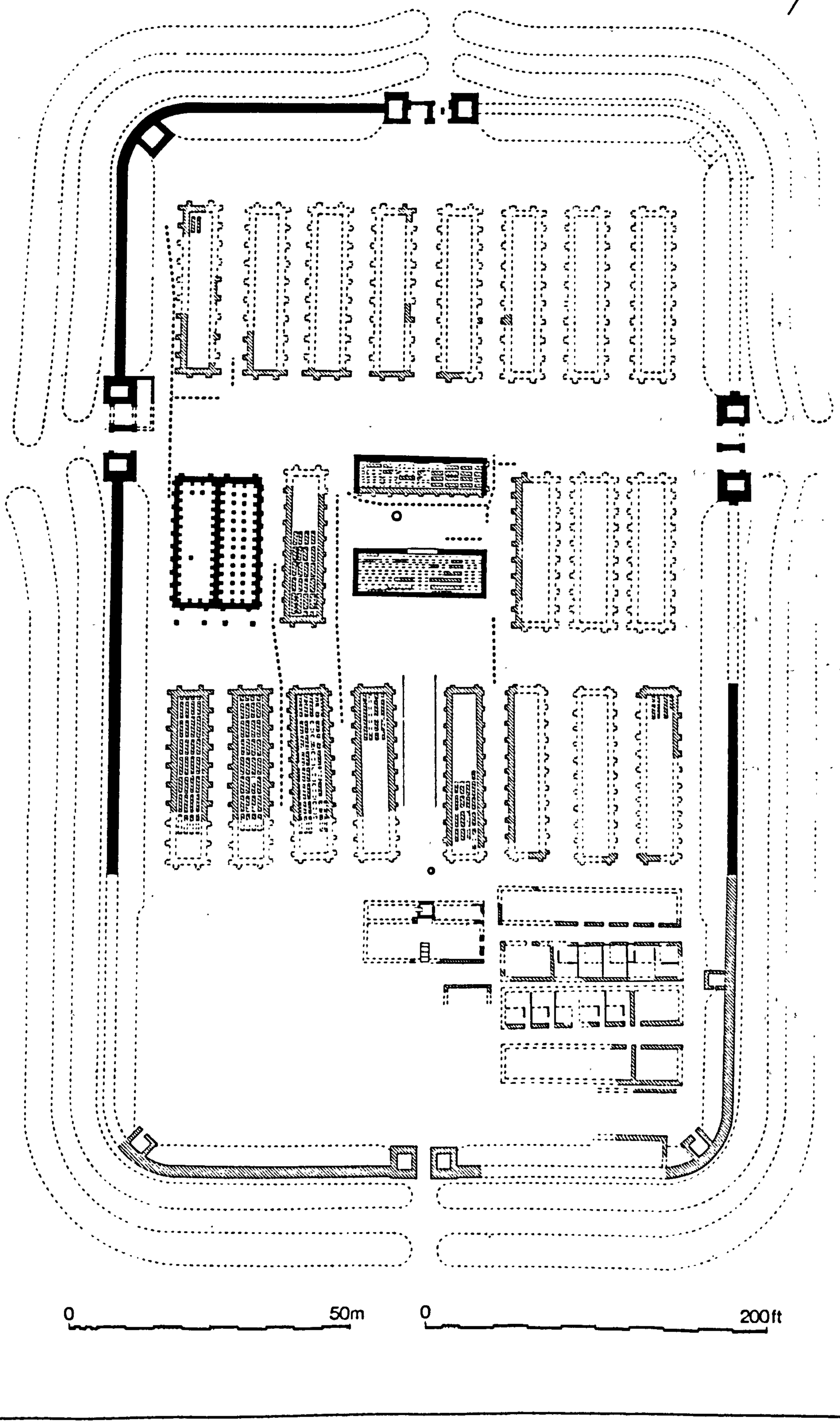
[1] Within the filling of a Period 5 water pit was discovered late 2nd to early 3rd century East Gaulish ware. Alleged late 2nd century BB2 bowls or dishes with rounded rims appear in a number of deposits of Period 4C, while very little evidence has been recovered in this context from earlier 2nd century dates (Bidwell and Speak, forthcoming, 42).
[2] The seals bear three heads and the inscription AUGG, that is, three emperors of whom only two were Augusti (see Dore and Gillam, 1979, 63). These can be only Severus, Antoninus and Geta, at a time after 198 when Antoninus became Augustus alongside Severus, and before 209 when Geta became Augustus (Dore and Gillam, 1979, 63).
[3] They were all made of mostly buff sandstone, some pink micaceous sandstone and a little magnesium limestone, and a rubble and mortar core.

the construction occurred during a general period of restoration of Wall structures as well as bridges at Chesters, Corbridge, and Willowford under Severus, before his Scottish campaigns (Bidwell and Holbrook, 1989, 138-40). In this case, supplies destined for North-eastern forts which may have been stored in extra-mural facilities, were now stored intra-murally in the Severan period fort. However, it is far more likely that the granaries were constructed in preparation for the campaigns ca 208-11.

First, a link may have existed between South Shields and Cramond on the Firth of Forth. An altar (RIB 2134) found at Cramond was inscribed by the same unit as has been attested by lead seals at South Shields (cohors V Gallorum), suggesting a sea-borne link between the two forts. This link, together with the unusually large size of the fort at Cramond (2.43h), apparently holding only a quingenary equitate unit (Bidwell and Speak, forthcoming, 46), suggests that the fort served as a distribution centre for supplies, and that part of cohors V Gallorum may even have been posted to Cramond because of the unit's experience in administering supply systems (ibid, 48).

Second, as will be discussed (6.2.1), two granaries at Corbridge were rebuilt, and possibly two more very large granaries constructed under a praepositus at Corbridge during the Severan campaigns: it is likely that the South Shields granaries were constructed to hold grain destined for the Corbridge granaries and the army moving north into Scotland along Dere Street.

Fig 14: Period 6 post-Severan fort at South Shields, from Biwell and Speak, forthcoming.



Post-Severan to 4th Century: Period 6. It has been argued (Dore and Gillam, 1979, 66) that the Severan granaries were used as such only for the duration of the Scottish campaigns, on the basis of dating evidence for the conversion of some of the granaries into barrack blocks: ie the recovery of a coin of Julia Domna dated to 207-11,[1] as well as two and possibly three mid-Antonine sherds recovered from blocked vents in granaries C10 and C11 (Dore and Gillam, 1979, 42, fig 39, numbers 138-40). However, the wall within which the coin was recovered is now argued to belong to the Period 7 rebuilding (Bidwell and Speak, forthcoming, 38), while the pottery may have been survivals. Conversely, evidence recently recovered suggests that the granaries and certain fort buildings continued in use long after the Scottish campaigns.

First, a post-Severan building phase of the granaries has been identified (Bidwell and Speak, forthcoming, 36). Six new granaries were built in the south-east row, while another was constructed from the forecourt of the old principia, now re-sited south-east of the granaries. These new granaries constrast in style with the Severan phase of construction, having eleven, rather than ten buttresses along the side wall, and with ends off-set, rather than flush. In total, the Period 6 supply base, belonging to the first quarter of the 3rd century, contained twenty-four granaries, arranged in three rows of eight across the width of the fort (ibid., 42).

---

[1] It was found in the cobble foundations of the west forecourt wall of the south-east facing principia.

Second, evidence from pottery and coins has proven that principia and barracks of the 3rd century in the south-east part of the fort continued in use until a fire in the fort in the last quarter of the 3rd century, or possibly the first quarter of the 4th century (see figure 14; Bidwell and Speak, forthcoming). The restoration after the fire included re-instatement of the headquarters building in lieu of two granaries, and construction of ten barracks south-east of the central range, eight re-using the walls of the south-east row of granaries (ibid., 38). Whether the twelve granaries north-west of the central range went out of use is not yet known. However, nothing yet suggests that the fort lay-out had changed between the time of the Period 6 restoration and the fire near the end of the 3rd century. Therefore, it is likely that the granaries continued in use throughout the 3rd century, and that the granary capacity of the fort increased after the Scottish campaigns.

The continuation and expansion of granary space in Period 6 begs the question: for whom was the grain destined? The grain was definitely not stored for forts in Scotland, as the only forts remaining in occupation north of the Wall in the east of Britain after Severus' withdrawal were Risingham and High Rochester. Some of these supplies may have been for the Classis Britannica, as sea-faring beyond the Tyne would have required a supply base (Bidwell and Speak, forthcoming, 54). Indeed, inscriptions record the fleet building at Benwell (RIB 1340) and along the curtain between Birdoswald and Castlesteads (RIB 1944-5), as well as a command over the fleet of Britain, combined with those of Germany, Moesia and Pannonia (CIL IV, 1643; Bidwell and Speak, forthcoming). However, apart

from these inscriptions, very little is known of the fleet, and sea-faring beyond the Tyne may have been very minimal. Alternatively, some supplies may have been ear-marked for subsidies to the native population beyond the Wall after the Severan Scottish campaigns (Bidwell and Speak, forthcoming, 48, 55). It seems that such subsidies were paid (as well as garrisons removed from enemy lands) after the Danubian Marcommanic Wars (Frere, 1987, 149). In addition, according to Themistius (Orat 10.15B), peace was sometimes bought with grain and ship-loads of clothing.

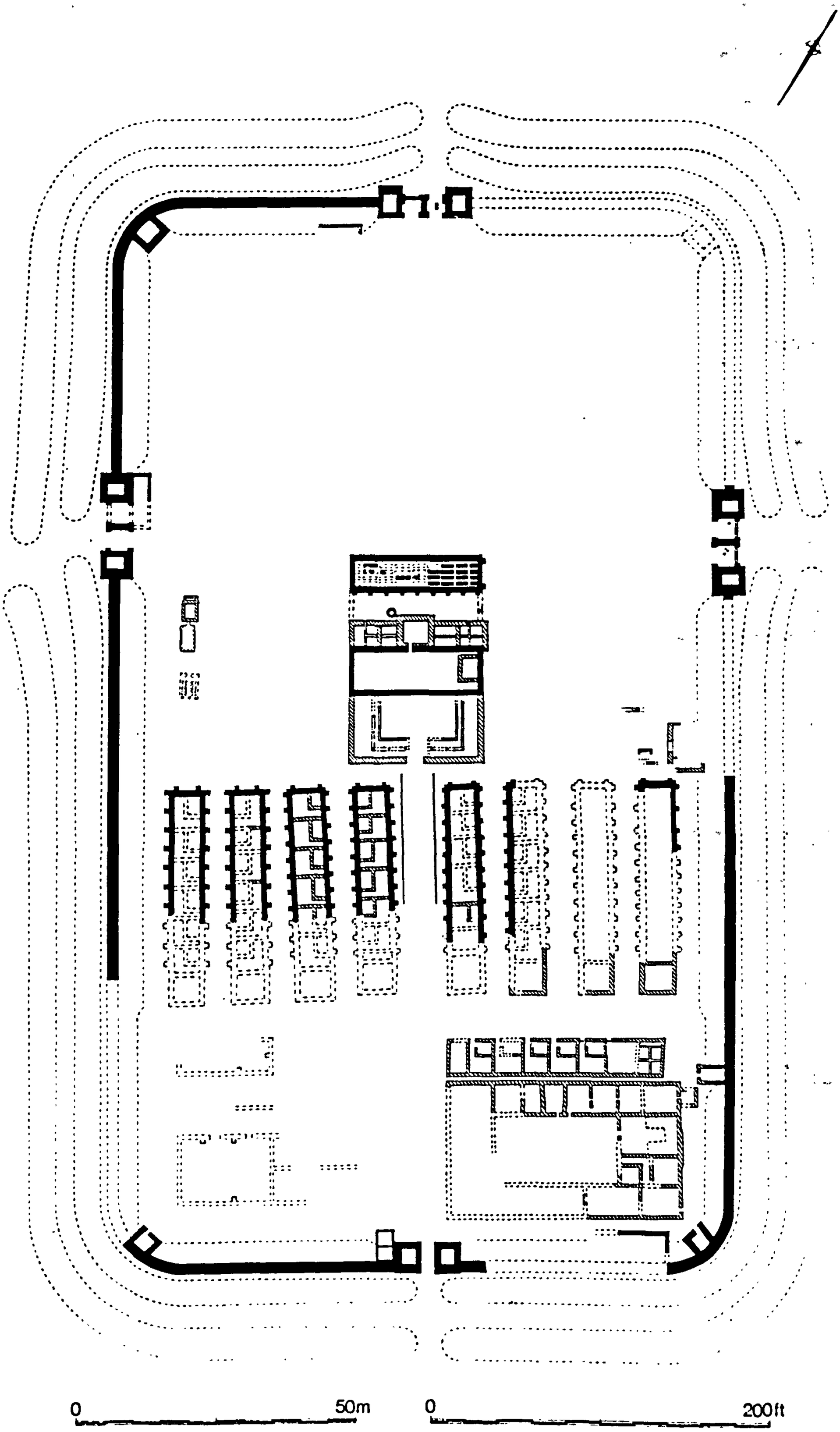
However, it is likely that most of the grain supplies were intended for forts in the North-east. Indeed, as will be discussed (Appendix H-3; below, 6.2.3), due to soil denudation and degradation, it is possible that by the 3rd century the army's grain supplies could no longer even be supplemented adequately by local production, so that imported grain had become essential to meet the army's demands. It seems that the expanded granary space would have ensured enough grain for 10,215 men for one year.[1] This conforms well to the reduction of manpower in the North-east from a high of 17,000 at the beginning of the 3rd century, to an estimated one third that amount by the end of the century (Breeze, 1984, 268). Therefore, after the Severan campaigns, the original extra-mural granaries (if they existed) were abandoned. The Severan

---

[1] The capacity increased from 2706 tonnes in the Severan construction to 3355.6 tonnes (Bidwell and Speak, forthcoming, 49): at .9kg necessary per soldier per day (Polybius' estimate: see Appendix H-1), the expanded granaries could have supplied 10,215 men with grain for one year.

Fig 15: Period 7 4th century (?) fort at South Shields,

from Bidwell and Speak, forthcoming.



intra-mural granaries were kept in commission, and new granaries constructed, all or most of which now held supplies destined for North-eastern forts.

Period 7. The Period 7 construction was a result of what is thought to be an accidental (as opposed to deliberate demolition before rebuilding) fire in Period 6 (Bidwell and Speak, forthcoming, 62; see figure 15).[1] A general period of restoration during Constantine's visits to Britain in 312 and 314, which saw the establishment of the dux Britanniarum and the abandonment of the outposts (Casey and Savage, 1980, 79-80) may provide an historical context for Period 7. Such a context is also supported by available coin evidence.[2] In addition to various structures either constructed or restored,[3] eight granaries in the north-western part of the fort remained in use.

---

[1] A .3m layer of burnt daub covers most of the area, a .4m layer is sealed beneath a later road between the barracks and granaries, burnt material was found in the lowest filling of the strong-room of the Period 6 principia, burnt grain in the forecourt granary reflects damage to the granaries, and burnt material lay over the street north-east of the forecourt and forehall granaries (Bidwell and Speak, forthcoming, 61).
[2] A coin probably of Carausius or Allectus dating to the end of the 3rd century has been found in a Period 6 barracks, as well as two radiate copies and a coin probably of the same date in the Period 7 reconstruction of the principia, while twenty-seven coins, of which seven radiates or radiate copies are the latest issues, have been found in the eastern corner of the fort in Period 6 demolition or Period 7 construction levels (Bidwell and Speak, forthcoming, 81).
[3] Construction included ten barracks in the praetentura, eight of which used the remains of the south-east granaries, a large courtyard house in the eastern corner of the fort, and two tile kilns over the double granary of the original stone fort (Dore and Gillam, 1979, 29-32), while restoration included the Period 4 and 5 principia with new forecourt (Bidwell and Speak, forthcoming).

Indeed, the principia was rebuilt southwards to face the area containing the barracks and courtyard house, thus reverting to the orientation of the original principia. If the granaries had fallen out of use, it is likely that the principia would have been built facing north, so that the via principia and via praetoria would have led to the proper gates for which they were designed (Bidwell and Speak, forthcoming, 75). This orientation, then, suggests that the north-western row of eight granaries continued in use during Period 7. Again, it is possible that the overall reduction of granary space from Period 6 was due to the continued decrease in numerical strength of the North-eastern garrison in the 3rd century.

Later Periods. Period 8 entails a series of modifications to buildings in the second half of the 4th century. As for the granaries, C1 and C2 of the north-east row were converted to other uses by the removal of their raised floors (Dore and Gillam, 1979, 42-4). By the end of the 4th century, the forecourt granary was converted by replacing a raised floor with a solid one. On present evidence, it appears that if some of the granaries survived into Period 7, by Period 8 even more had gone out of use.

Barcarii

Evidence suggests that barcarii stationed at South Shields were involved in a Piercebridge formula supply system. First, it seems that the unit was stationed at South Shields at the beginning of the 4th

century, at a time when the fort functioned as a supply base.

The unit is listed as praefectus numeri barcariorum Tigrisiensium in the Notitia Dignitatum, and it is likely that the overall command of the Dux Britanniarum began during the first quarter of the 4th century (Dore and Gillam, 1979, 69). Indeed, a Birdoswald inscription (RIB 1912) attests to a praeses commanding the Wall garrison, precluding the existence of a dux before 296-305, while the designation of equites at Danum as Crispiani (Caesar Crispus, 317-326) suggests that the units were established before 326 (ibid.). In addition, it is argued (Kennedy, 1986) that these bargemen, described in the Notitia as a numerus barcariorum Tigrisiensium, would have been recruited from a stretch of the Tigris known as Bet Arbaye, which was under Roman control between the reigns of Septimius Severus and Julian. Furthermore, if in residence at the beginning of the 4th century, the arrival of this numerus, in addition to the garrison already in residence - cohors V Gallorum - may have occasioned the re-planning of the fort in Period 7 (Bidwell and Speak, forthcoming).

That South Shields was receiving supplies at the beginning of the 4th century is suggested by two things. First, the possible continuation into Period 7 of eight granaries in the fort's north aspect suggests intra-mural storage of imported supplies. In addition, as discussed below (Appendix H; 6.1.3), because of the likelihood of soil degradation and denudation occurring in the North-east, by the 4th century South Shields most likely had become vitally important as a port receiving

imported supplies such as grain for forts in the North-east.

The role of this unit in supplying forts upriver from the supply base is suggested by an inscription (RIB 601) recording barcarii at Halton-on-Lune, 5km upriver from Roman Lancaster (Shotter, 1973, 206).[1] Although the dating of this inscription is uncertain, the ala Sebosiana resided at Lancaster in 262-6 (RIB 605), suggesting the barcarii were stationed there after that date, and probably not later than the 3rd century (Bidwell and Speak, forthcoming). If found in situ, barcarii seem to have been operating upriver from a Romano-British fort, perhaps at about the same time as barcarii were stationed at South Shields.

Also, antiquarian accounts attest to what may have been Roman period docking facilities below Wallsend fort. Wallis (1769, vol 2, 253) writes of a causeway[2] running from the fort to remains of a Roman period quay in the river, and Mackenzie (1825, 465) writes:

> "I have frequently after high tides observed large, well-wrought, ashler stones lying on the shore of the river at the foot of this field, the scattered ruins probably of a [Roman period] key."

Finally, some very circumstantial evidence suggests river transport as far as Benwell (discussed in detail below, 6.3.1).

---

[1] It is a dedication to Mars made by the P[rae]p[ositus] et milit[es] n[umeri] barc[ariorum].
[2] However, Bruce (1851, 113) considered this causeway rather the eastern part of the Wall brought down to the river.

4.1.2 Evidence Refuting the Piercebridge formula

Barcarii

However, even if evidence at Wallsend and Benwell suggests operations by barcarii upriver from South Shields, such activity would have been well within the tidal limit of the Tyne, and below the point at which the river development would have commenced. Therefore, such evidence does not in fact support the development of the Tyne according to the Piercebridge formula. On the other hand, it is possible that barcarii were involved with operations solely within the area of the fort and river mouth, and perhaps beyond the mouth to a certain extent.

Operations at the river mouth. The unit of barcarii may have functioned as 'guides' for the supply ships sailing into the dangerous waters of the Tyne's mouth. Indeed, before 19th century dredging operations, the river mouth was rife with shoals and bars. As described by P J Messent, engineer to the Tyne Commission in 1849 (Johnson, 1895):

> "a Bar ... 6 feet [1.8m] at low-water spring tides ... extended 800 feet [240m] from west to east, and the width of channel over it was about 600 feet [180m]. About 1100 yards [910m] above the outer bar was an inner bar, called the 9 Feet Bar, and stones. About 400 yards [364m] above the 9 Feet Bar the channel was abruptly reduced in width to 400 feet [120m] opposite the Low Light House, the contracted channel being called the Narrows. Shields Harbour, about a mile and a half [2.4km] in length, which commences above the Narrows and extends to the high end of South Shields, opposite Whitehill Point, consisted of a comparatively narrow, tortuous, deep water channel, with large shoals on either side dry at low water, some of which, the In-sand and Middle Ground on the south, and the Dortwick Sands on the northside of

> the harbour, extended from the shores to and beyond the middle of the river. It required very careful navigation to take a laden vessel out of Shields harbour at high water (the only time possible) and keep clear of the shoals."

Indeed, navigation through the river mouth could be very hazardous

(ibid., 14):

> "...mighty surges ... seethed over the treacherous Black Middens, or thundered the Herd Sand in a north-easterly gale. To get over the Bar in such a gale was a feat of seamanship ... every winter strewed the entrance to the harbour with wrecks, and in no stinted numbers. Thirty stranded hulls have been counted together after one storm. The Tyne was a notoriously dangerous port, to which the prudent seaman always gave a wide berth in bad weather, or if he had the temerity to essay an entrance he was often glad to save his ship by running her high and dry on the South Sands... vessels sometimes spent a month waiting for sufficient water to get past the "Middle Ground" and "Dortwick Sands" to sea."

These hazards may have been even worse in the Roman period. Given the rates of alluviation in the Roman period along the Tyne catchment, as well as the lower sea and river levels, bars and shoals may have been even more obstructive. Therefore, barcarii skilled at navigating a silt-prone river such as the Tigris (see Appendix G-6) may have been brought to South Shields to assist navigation by guiding flat or round-hulled ships (discussed below, 6.1.2) around the dangerous shoals and through the channels of the river mouth.

Such navigation seems to have been the function of a unit of barcarii undertaking shallow water trans-shipment of cargo (Anon, Notitia Dignitatum Occ. 35, 32) at Bregenz on Lake Constance (Middleton, 1979, 82), possibly in conjunction with the Lake Constance fleet, which from 260, was intermittently centred at Bregenz (Bidwell and Speak, forthcoming, 79).

In addition, barcarii may have been involved in unloading supplies from ships. Unloading flat-bottomed ships may not have been difficult. Once into port, these ships would have been manouevred into shallow waters until the ebb-tide had deposited them onto the beach (Monaghan, 1987). However, unloading round-hulled ships which could not have been beached may have required skilled bargemen acting as 'stevedores'. Indeed, the notorious shoals and bars, together with tides and winds at the river mouth would have rendered these ships vulnerable, and conditions may have demanded quick and efficient unloading by skilled bargemen.

Once supplies had been unloaded, barcarii may have delivered them to the fort. Bidwell and Speak (forthcoming) argue that if the river mouth was the same in the Roman period as the Medieval,[1] the closest point suitable for a port would have been immediately to the west of the In Sand, where the main river channel veered towards the south bank, ca 400m from the fort.

---

[1] Excavations carried out in 1990 west of the In Sand (Bidwell and Speak, forthcoming) revealed that at least 60m width of foreshore has been reclaimed since the late medieval period. Also, a sherd of Nene Valley colour-coated ware of the 3rd-4th century was found through layers of sand and gravel between the reclamation deposits (ibid.).

Operations beyond river mouth. The unit of barcarii may have been involved with defence of the river mouth from a sea-borne threat (Dore and Gillam, 1979). In addition to barcarii, the Notitia mentions nine other numeri, three units of cavalry and a legion, and a collection of cohortes and alae along the line of the Wall. The legio, equites and numeri of the main part of the Duke's command together formed a mobile tactical group which was intended to reinforce the static troops on the frontier and perhaps to repulse sea-borne attacks on the north-east coast (Dore and Gillam, 1979, 69):

> "[This system] ...has all the elements of a coherent, localized, defensive group: legionary infantry supported by highly mobile cavalry units with the more specialized numeri, (barcarii, vigiles, exploratores, directores, defensores), placed at strategic intervals ... during the last stages of the Roman period, these units may have been called upon to take a more combatant role in the defense of a river estuary against sea-borne incursions."

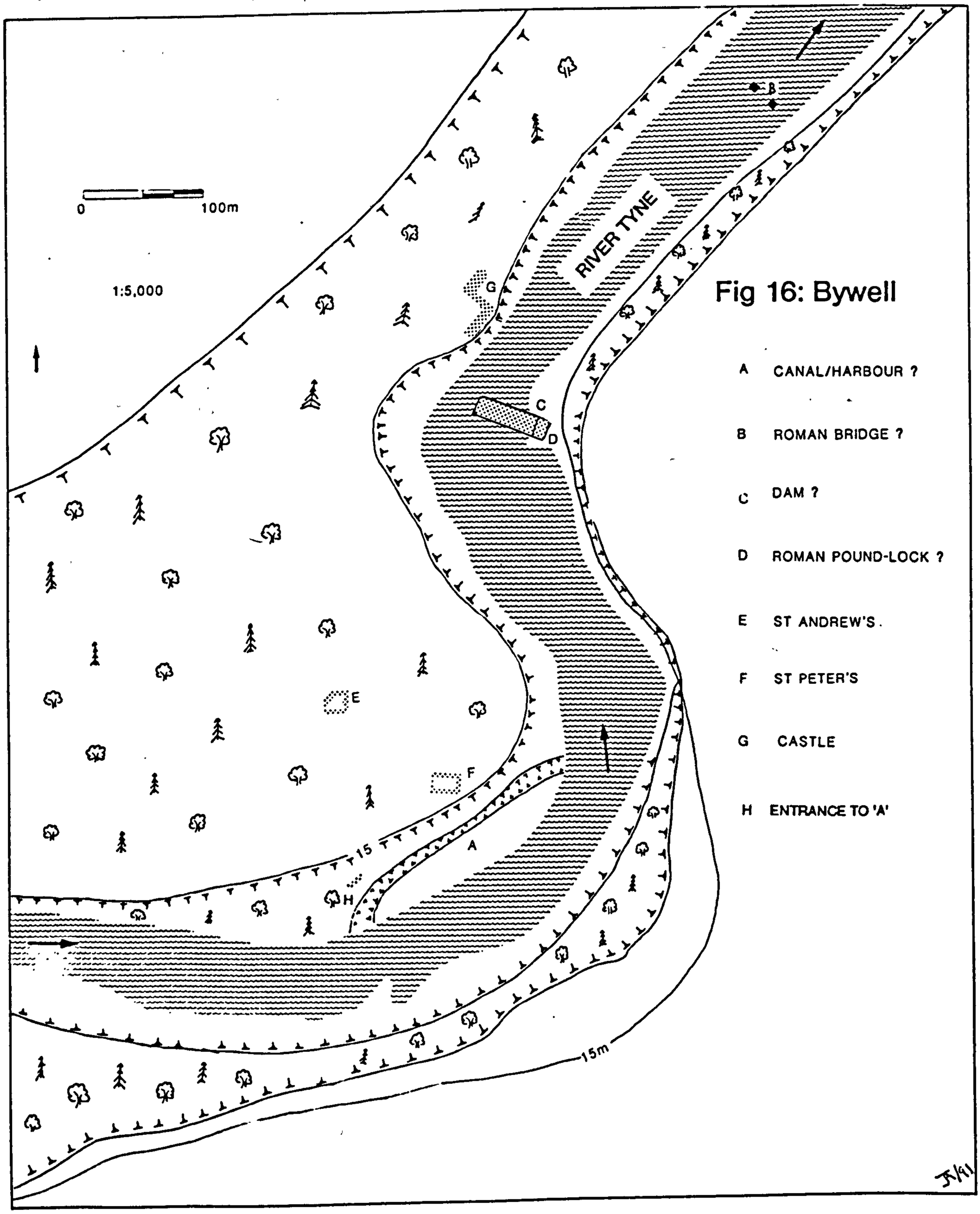
However, large-scale combat on the open sea seems an unlikely role for this unit. Indeed, their title numeri barcariorum Tigrisiensium suggests rather the use of small boats upon a river, rather than fighting ships on the often turbulent waters of the North Sea. If indeed a sea-borne combat unit, it may have been involved with no more than preventing enemy ships from either attacking supply ships during the slow and cautious navigation through the river's mouth to South Shields, or sailing through the Tyne's mouth and penetrating the area behind Hadrian's Wall. Rather, naval engagements on the open sea are more likely to have been carried out by the Classis Britannica.

4.1.3 Conclusion

On present evidence, South Shields conforms to a Piercebridge formula supply base receiving sea-borne shipments at a river's mouth. By the Hadrianic period, the fort may have received some supplies for delivery to forts east of Portgate along the Wall. Although at least some if not most of the grain demanded by the army could have been met on a local level before the Severan period (discussed below, 6.2.3), some grain as well as other supplies could have been held in as yet unidentified storage facilities. That such storage facilities existed outside the Antonine fort precincts is given weight by the rise to pre-eminence of South Shields as an important port by the mid-Antonine period (below, 6.1.3), receiving supplies for forts in perhaps all three areas of the North-east. The significance of this fort is underlined by its choice as a base for supplies for Severus' campaigns into Scotland. Severan period granaries were constructed intra-murally to hold grain for the advancing army. With the eventual withdrawal from Scotland, the Severan granaries were kept in commission, and additional intra-mural granaries were constructed. It is possible that this marks a switch from reliance upon hitherto unidentified external granaries to intra-mural granaries. In addition, the large granary space of the 3rd century fort may underline a new dependency upon large amounts of imported grain to the North-east (see Appendix H-3). These granaries and therefore foreign import continued, although on a gradually reducing scale with a decrease in manpower in the North-east during the Roman period.

However, although evidence upriver awaits examination (below), no evidence at South Shields suggests that barcarii operated above the Tyne's tidal limit and navigated a river developed with Piercebridge formula components. Nor were they brought from the Tigris to South Shields because they were specially-skilled in navigating such components. On the contrary, as discussed in Appendix G-6, due to shoals and shallows which rendered many stretches of the Tigris unnavigable, river-borne transportation was carried out along the Tigris only when the river was naturally navigable.

If indeed brought from the Tigris for their barge navigation skills, it is more likely that barcarii were to act as guarantors to the sea-borne supplies putting into South Shields port. Barcarii may have overseen the operations of the harbour, and focussed on no more than facilitating the navigation of ships through a river mouth made hazardous by a combination of unpredictable shoals, currents, tides, and storms, as well as protecting the river mouth itself against penetration by enemy ships.


0
100m
1:5,000
RIVER TYNE
B
G
C
D
E
F
H
A
15
15m
Fig 16: Bywell
A CANAL/HARBOUR ?
B ROMAN BRIDGE ?
C DAM ?
D ROMAN POUND-LOCK ?
E ST ANDREW'S .
F ST PETER'S
G CASTLE
H ENTRANCE TO 'A'
JK/41

4.2 BYWELL

It is argued that certain structures at the hamlet of Bywell, situated ca 47km up the River Tyne from South Shields, 15.8km from the tidal mark, and on the north bank and in a bend of the river, are representative of Piercebridge formula supply (Selkirk, 1983, 134-6). The site had a Roman period occupation, canal/barge harbour, bridge, dam, and pound-lock (ibid.).

4.2.1 Evidence Supporting the Piercebridge formula

Stone found in St Andrew's Church suggests Roman period occupation on the site: three stones with lewis holes from a Roman bridge, and twelve stones used originally as Roman lavatory seats are contained within the bell tower (Selkirk, 1983, 137; see plate 16, 17). As both churches were in existence in 803, the stone used to build St Andrew's would have come from a nearby Roman ruin (ibid., 136). Further, a Roman cup found in 1760 in the river near Bywell suggests Roman period occupation in the vicinity (ibid., 136).

A 'V'-shaped water course running south and parallel to St Peter's Churchyard, leaving the Tyne 350m upstream from the ruined weir (NZ048613) and rejoining ca 250m downstream (NZ050614), represents a canal/barge harbour (Selkirk, 1983, 135; see figure 16: A). Masonry blocks form an entrance to this canal at its west and upstream aspect, which is "identical to the entrances of the channels at Piercebridge,

Plate **16**

Stone with 'lewis-hole'
St. Andrew's Church,
Bywell.

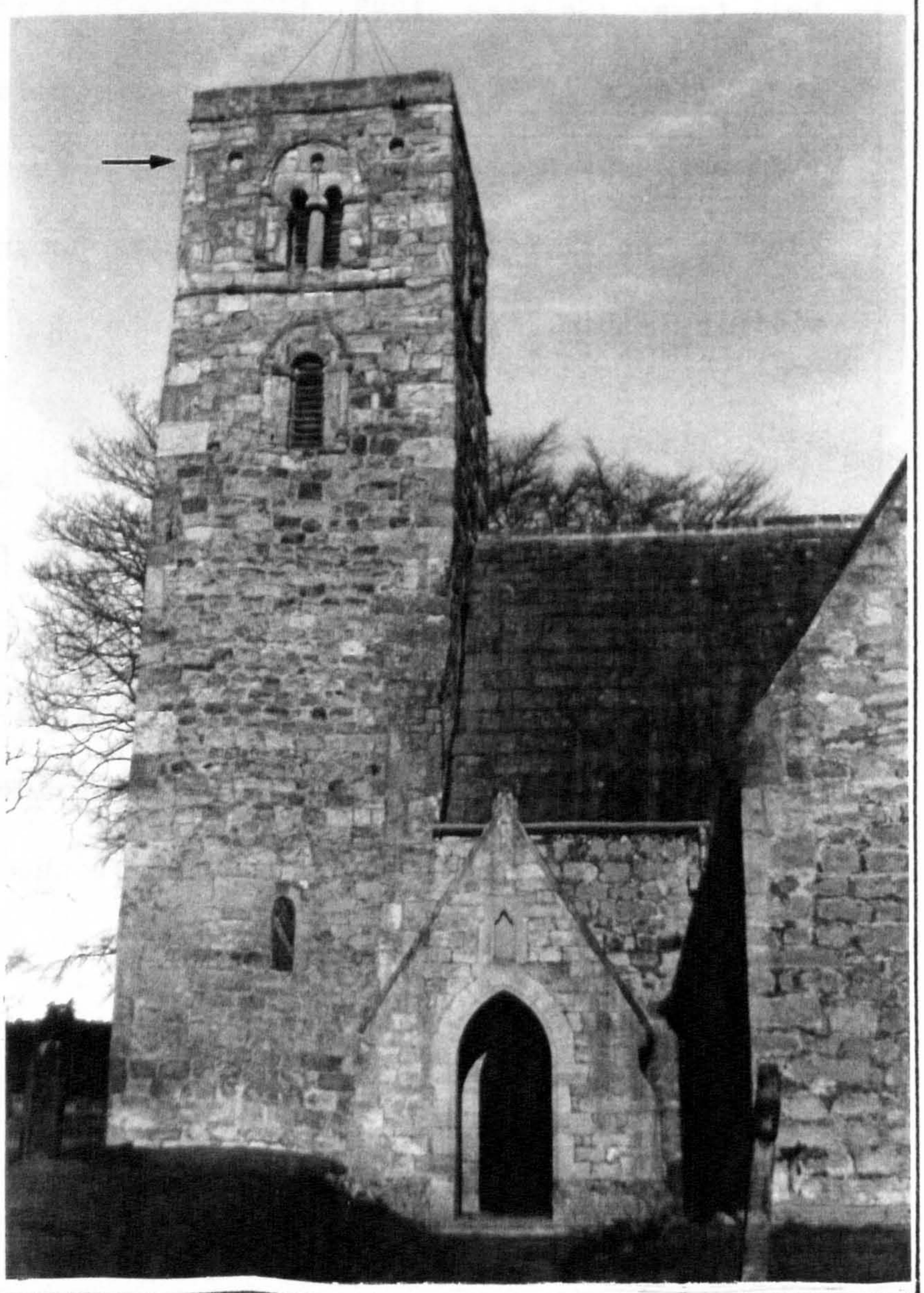


Plate **17**

St. Andrew's Church,
Bywell, with 'sounding-holes'
in bell tower.

Bowes, and Crackenthorpe" (ibid; see figure 16: H).

A Roman bridge is attested by historical accounts of two piers destroyed in 1836 (ibid.). Camden (1637, from Selkirk, 1983, 135) states that "beneath the castle...[were] two solid piles of most firm stone, which in time past supported a bridge, standing up in the midst of the river". Another source[1] writes "...on the two piers, there was no spring of arches, so the superstructure must have been made of wood", suggesting a Roman bridge of wood built over stone piers.

A Roman bridge is also attested by an engraving of 1834 depicting piers standing independently: such bridge construction follows Roman rather than Medieval convention (Selkirk, 1983, 136; see plates 23, 24). Furthermore, lewis-holed stones have been found in the river (Selkirk, 1983, 137):

> "These stones were obviously from the ancient bridge and, as the church was built before 803, then so was the bridge and, as the bridge was in ruins when the church was built, it seems to place the bridge nicely in the Roman period."

Finally, a link has been made between the stones in St Andrew's and the bridge stones in the river (Selkirk, 1986, 2). As the pier spacing suggests three, rather than two bridge piers, and because St Andrew's Church is closer than St Peter's to the bridge, "there is not much doubt that [the stones in St Andrew's] came from the missing pier of the suspected Roman bridge" (ibid.).

---

[1] This source is unnamed by Selkirk (1983, 135), and so remains anonymous.

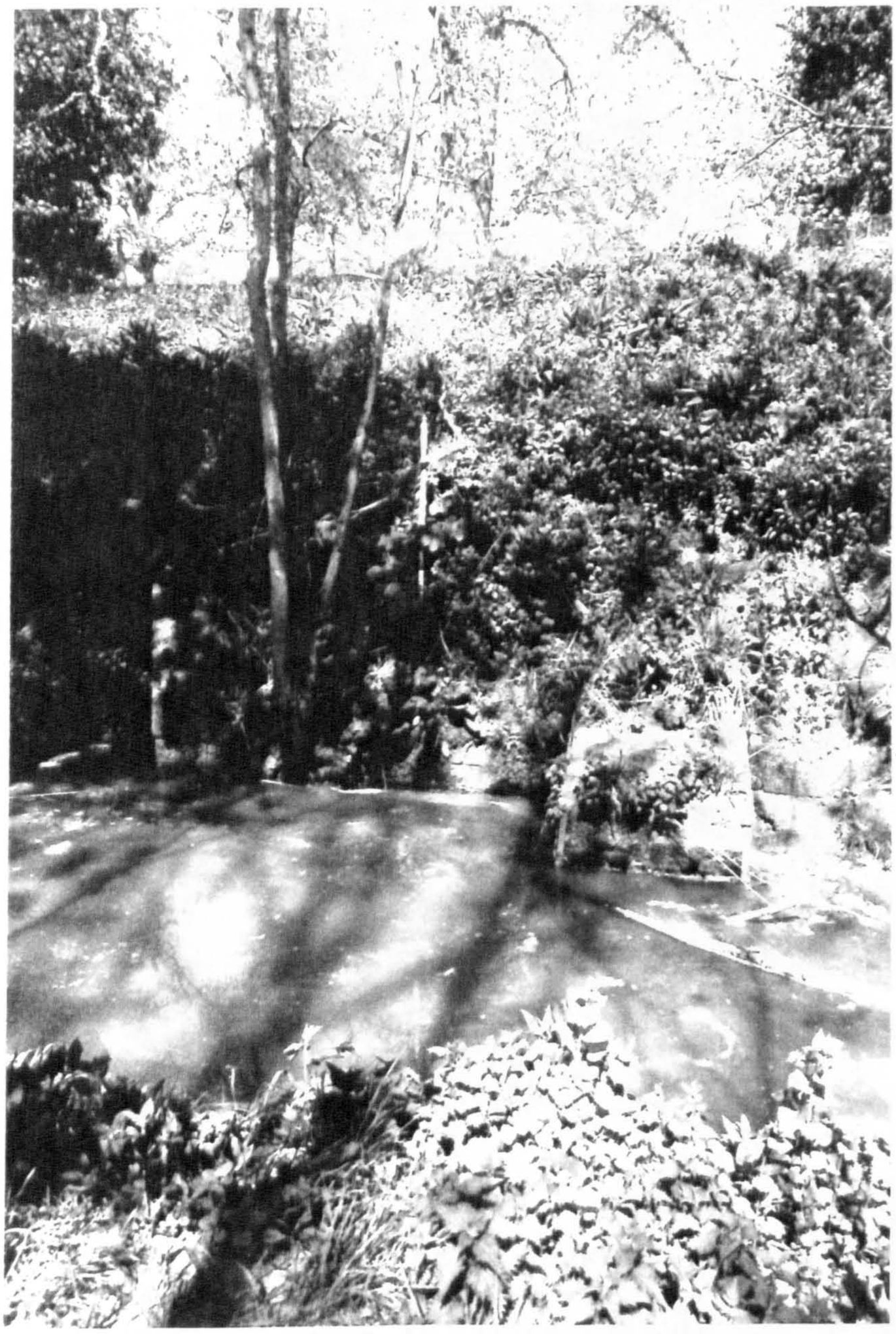
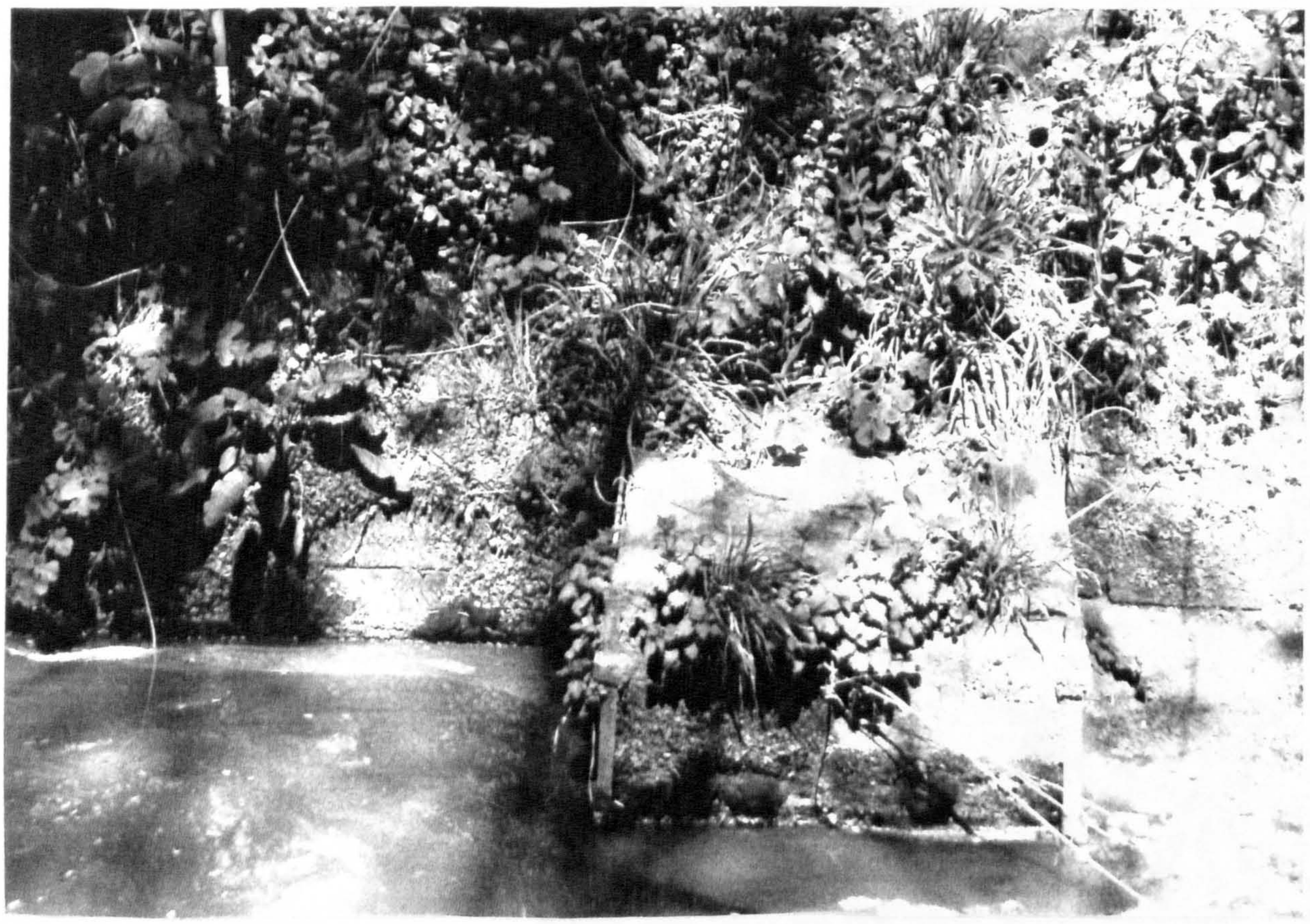


Plate 18:

Masonry in pool of soapy water near the top (west) end of back channel and likely terminus of sewerage system from Bywell Hall.



Three reasons suggest a Roman dam once existed on the same spot as the Medieval fish weir (Selkirk, 1983, 135-6, 138, 141). First, the weir's height was sufficient to fill the 'canal' with enough water to make it navigable. MacKenzie writes: "in a regular cascade, the whole river falls over a wear, ... in height about ten perpendicular feet [3.05m]" (from Selkirk, 1983, 135). Second, this dam was in use as early as 1268: if the churches were constructed before 803, it is likely that the 1268 dam existed at that period as well; if the dam was there before 803, it could have been built in the Roman period (ibid., 136). Third, the structure has the character of a Roman dam (ibid., 138):

> "I could see at a glance that the structure looked Roman. The dam started from a natural projection of the cliff face at the south side of the river, and large blocks possibly weighing 100 tons [90,900kg] or more had been shaped to form the end of the dam. Through this was a spillway cut out of the solid rock ... [with] a slot either for stop-logs or a lifting type of guillotine gate, and these slots were also cut out of the solid rock. Away from the cliff the construction changed from solid rock to large blocks of masonry tied together with iron cramps set in lead. These rocks have Roman-type toolmarks."

This dam also contains a Roman period pound-lock: just beyond the spillway is located a passageway with slots for guillotine-style gates, and a recessed section for a 'lifting type' bridge (Selkirk, 1983, 137).

4.2.2 Evidence Refuting the Piercebridge formula

Roman period occupation

Roman stone is indeed present at Bywell. As discussed in Appendix F, the lewis-hole did not re-appear into Britain after the Roman period until at least the late 15th century, and the bell tower of St Andrew's containing lewis holes is probably of the 11th century (discussed below). In addition, the lewis-holes appear on the visible, vertical side of the stone (see plate 16). However, if used as a lifting aid, they would have been on the horizontal aspect and out of view.

Nevertheless, rather than coming from Roman structures at Bywell, it is more likely that these stones were brought to Bywell from a known Roman site. Indeed, the complete absence of Roman period pottery and other artefacts from Bywell (OS antiquity card NZ 06 SW2) suggests strongly against a Roman period occupation.

In addition, on the basis of its inferior quality of masonry and quoinwork (Gilbert, 1946, 165-7), the tower containing the three lewis-holed stones and 'latrine seats' belongs to a period of construction later than the main part of the church and the bottom nine courses of the tower. The latter belongs to the 9th century, while the upper reconstruction of the tower has been dated to ca 1000 (ibid.), about two hundred years after the date suggested above. If building

material from a nearby Roman period occupation was available in the later reconstruction, it would have been at least as prolific in the earlier period, so that its total absence in the main structure is conspicuous.

Re-used Roman stone, together with the inferior quality of workmanship, suggests that the upper part of the tower was rather hastily reconstructed. Perhaps after its destruction, the builders endeavored to reconstruct the tower as quickly as possible, and looked beyond Bywell for ready-cut masonry.

Indeed, precedents exist for re-use of Roman stone from military establishments in Christian edifices considerable distances away. Along the Tyne, two inscribed stones (RIB 1300 and 1305) from Wallsend fort were built into the foundations of the north aspect of Tynemouth Priory ca 7km downriver (Collingwood and Wright, 1965, 430,432).

In the case of Bywell, the stone was probably brought from the ruins of the Roman bridge at Corbridge. Not only are lewis-holes common in the Roman bridge (see Bidwell and Holbrook, 1989), but the bridge masonry at Corbridge is conveniently situated for transport to Bywell, either along a track on the north bank of the Tyne, or upon rafts or barges downriver (discussed below, 6.3.3). Indeed, stone may have been loaded onto such craft from a proposed 9th century quay below the Roman fort at Corbridge, (discussed below, 4.3.3).

Additional evidence further recommends Corbridge as a prime 'quarry' of Roman stone. Stones in the quoins and tower base, as well as in the north wall of the nave in the Saxon church of St Andrew's in Corbridge were taken from the cistern and fountain at Roman Corstopitum (Iley, 1974, 201). Further, a Roman arch stands between tower and nave, an inscribed stone[1] was identified in the north-east angle of the church in 1760, a sculptured stone of a boar's head was found in 1883, and an altar stands in the churchyard outside the north transept (ibid., 202).

As for the 'Roman latrine seats', it is unlikely that these were used as such in any period, let alone the Roman. Set within a square stone, three on each side of the tower, with two on either side of the hood[2] between the corner quoins, and one within the hood, these holes are more likely to be part of the original church architecture, common to other Anglo-Saxon churches in North-eastern England. Indeed, downriver from Bywell at the church of St Mary the Virgin at Ovingham, similar holes are cut through a single square block of stone in the tympanum of the tower hood (Taylor and Taylor, 1965, 478). Again, at Billingham in County Durham, 9th century St Cuthbert's Church has similar pierced holes in the tympanum of its tower hood. Those on the east and west aspects are round, while those on the north and south are in the shape of eight-pointed stars (Taylor and Taylor, 1965, 68).

---

[1] LEG II AUG. COH IV FECIT
[2] The hood is a Northumbrian double belfry window.

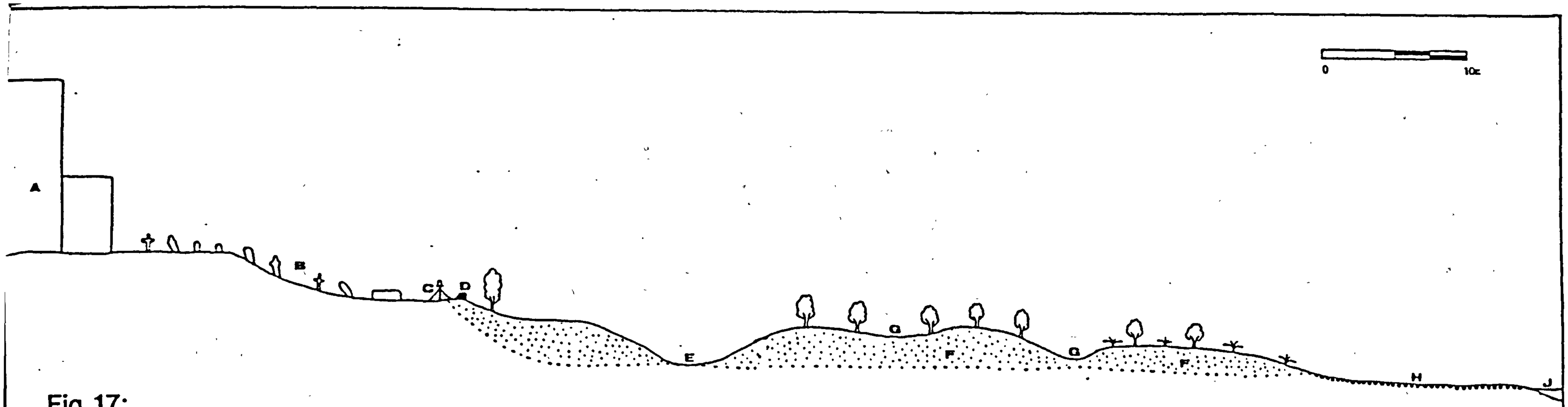


Fig 17:

Bywell Elevation showing 'By-Pass Canal' (Back Channel)

West facing East

May 9, 1991

1:4000

Key

A	St Peter's Church
B	Graveyard
C	Instrument
D	Churchyard Boundary Wall
E	'By-pass canal', or Back Channel
F	Point Bar
G	Ridge and Swale channels on point bar
H	Gravel and cobbles on Tyne riverbed
J	Present Height of Tyne River
.....	Projected Bottom of Alluvia
	Alluvia or river bed

JK

The holes in St Andrew's have been blocked from the back by what appears to be small brickwork, suggesting that the holes were closed-off at some period after the original construction. If the holes were indeed intended to remain open, they may have functioned as 'sounding-holes' for the bell tower (Gilbert, 1946, 164). Alternatively, they may have been small windows (Taylor and Taylor, 1965, 122). Whatever their exact function, they do not belong to a Roman context.

Finally, the silver cup is thought to be the fifth piece of a large hoard of Roman silverware, comprising among other items a decorated salver and bowl, found in 1731-6 in the river bank west of Corbridge (Daniels, 1978, 97).

In total, the complete absence of Roman period artefacts and pottery at Bywell suggests that the lewis-holed stones and cup represent secondary and transient material respectively, rather than material from a Roman period occupation of the site.

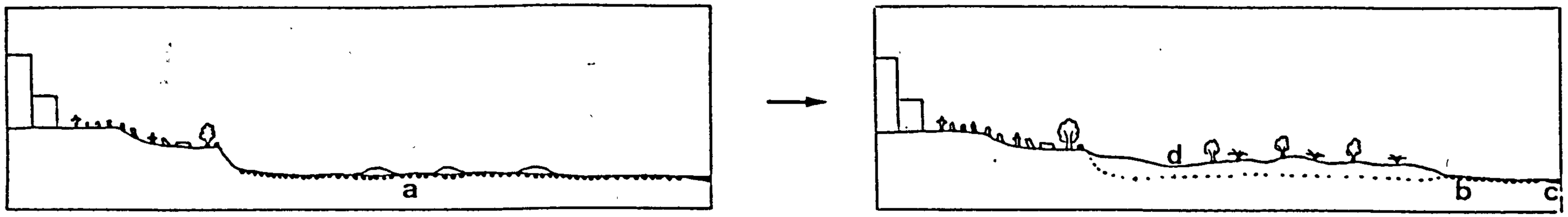
Canal/barge harbour

Rather than a Piercebridge formula component, the 'canal/barge harbour' is a feature formed by various forces, the most important of which is the dramatic annual flooding of the Tyne. The river at Bywell draws on a huge catchment comprising 2,175.6km sq (Jones, P D, 1977), fed mainly by the North Tyne and South Tyne uniting at Hexham. The North Tyne drains the south-east flanks of the Cheviots, including the entire

Fig 18: Episodic cycle of catastrophic stripping and vertical accretion for the flood plain below St Peter's Church at Bywell.

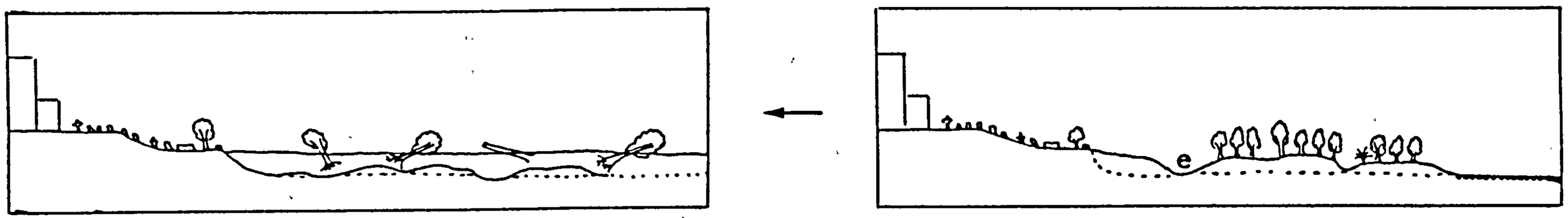
0 5Cm

1:12,500



Stage 1: STRIPPED: After catastrophic flood of Stage 4, vegetation and vertical accretion deposits are scoured to the gravel bed of Tyne (A).

Stage 2: BUILDING: Sediments near middle of channel (B) accrete laterally toward inside of bend forming point bar between main channel (C) and back channel (D).



Stage 4: CATASTROPHIC FLOODING: very powerful flood washes away point bar as far as the back channel, stripping vegetation cover; cycle begins with a stripped flood plain.

Stage 3: MATURE: The state of the Tyne today (see figure 18); with annual flood, point bar has increased in size, ridge and swale become more defined, and vegetation grows large enough to be generally unaffected; back channel continues to be scoured of sediments, so that the bottom of this channel, Selkirk's 'by-pass canal' (e) remains directly above the gravel bed.

F/a1

River Rede catchment, while the South Tyne drains the northernmost end of the Pennines, and is fed by two main tributaries, the Rivers East and West Allen. The result of this is that during periods of high precipitation, much water is released into the Tyne, so that, as mentioned (2.1.2), the Tyne at Bywell has the second highest recorded instantaneous discharge in Britain (ibid.).

In addition, flooding at Bywell would have been much greater in times past than it is now. Less water feeds the Tyne from its catchments due to the Catcleugh reservoir (1905) on the Rede, and the Kielder reservoir (1978) on the North Tyne. Before these reservoirs were constructed, and even after the weir downstream was destroyed (1862), the area below Bywell was given the name 'Bywell Bay'.[1] This 'bay' covered a large flood-plain south of Bywell and at a point where the Tyne bends 90 degrees to the north.[2] The extent of the flood-plain is illustrated on figure 19. This map, drawn after the 1862 weir demolition, shows the 'braiding' of the channel across the flood-plain.

---

[1] An oral account given to A S Phillips in 1956 by the Reverend Blathwayt, vicar of St Peter's Church, Bywell: OS antiquity card NZ 06 SW2.

[2] Situated adjacent to a river channel, a 'flood-plain' is covered with water when the river overflows its banks, and consists of deposits of vertical and lateral accretions of colluvium, channel deposits and overbank deposits (Bates and Jackson, 1980, 235).

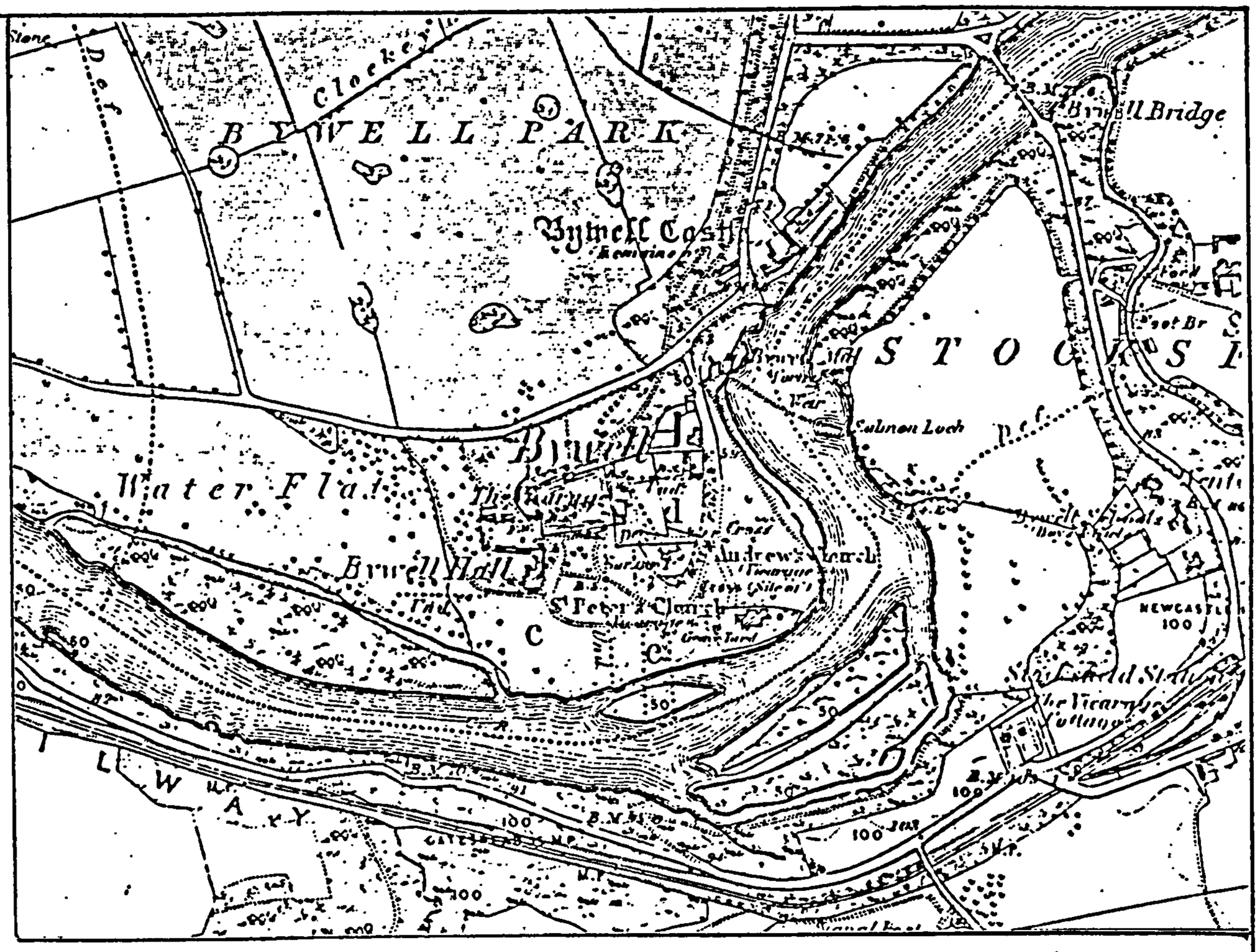


Fig 19: Bywell OS,1862, 6 inch.

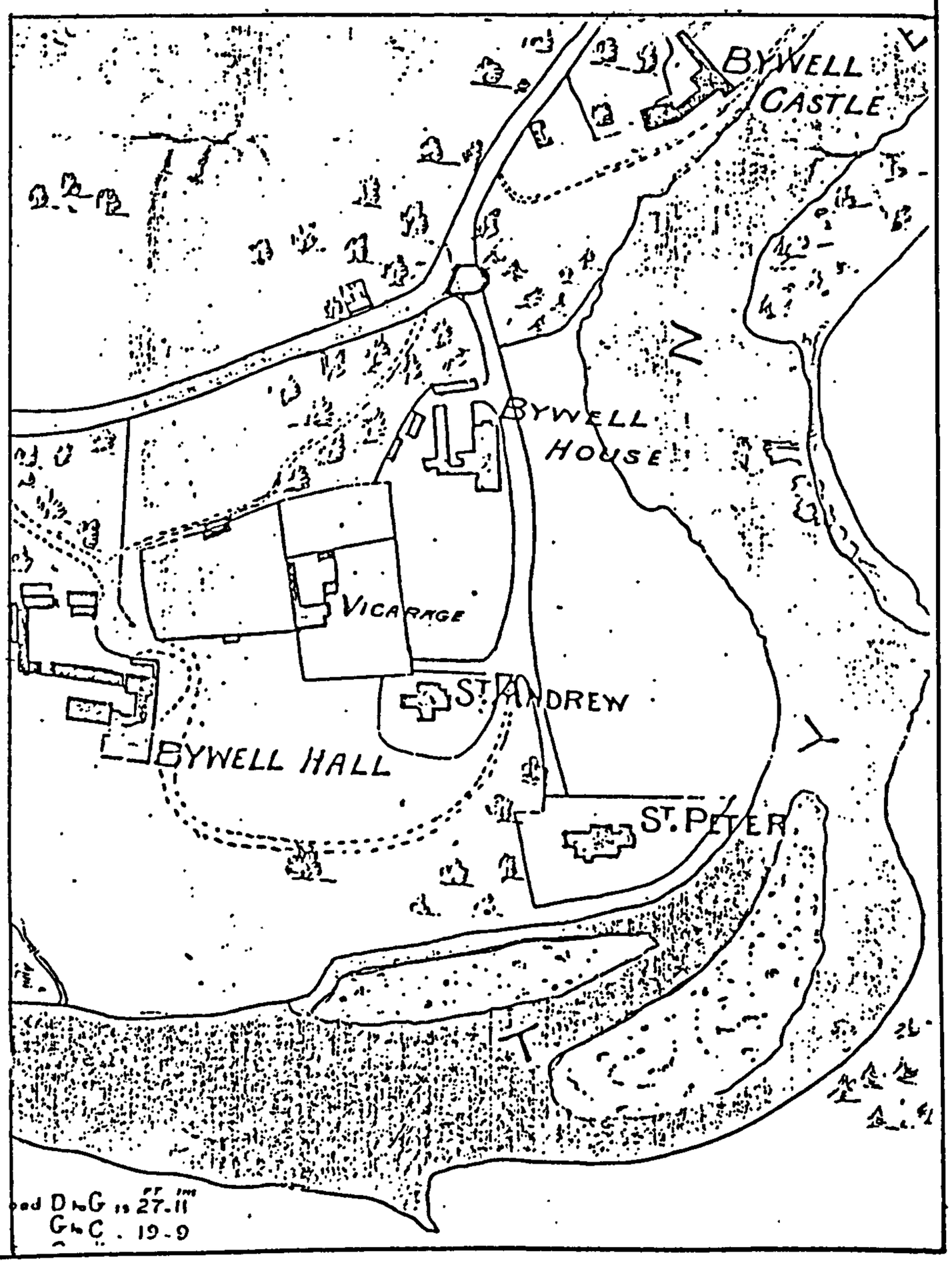


Fig 20: Bywell, 1910.

The feature described as a 'by-pass canal' within this flood-plain can be explained best by a series of stages (see figure 18).[1] It is likely that the bend in the river was severely scoured at one point by a large flood which occupied the whole valley width (see Stage 4, figure 18; Nanson, 1986). This episode stripped the channel bank, as well as floodplain vegetation and fine-grained verticle accretion deposits, until only the gravel bed of the Tyne remained. Thus Stage 1 (see figure 18) of the cycle begins with a stripped Tyne channel.

Stage 2 begins with the flood plain gradually reforming by vertical accretion of sediments. Those deposited near the middle of the channel, accreting laterally toward the inside of the bend, form a 'point bar' (see plate 20) (Lewin, 1978; Morisawa, 1985, 119) between the main and 'back channel' (Nanson, 1986). The back-channel at Bywell represents the Piercebridge formula 'by-pass canal' (see figure 17, plate 19).

The next stage occurs with the next flood. Overbank flooding at Bywell occurs on an annual basis, peaking at the end of January (Jones, P D, 1977, 4). Although not inundating to the extent of the massive flood occurring before Stage 1, the annual flood inundates both the point bar and back-channel (see Stage 3, figure 18). With recession of the flood, both the point bar and back-channel are scoured. It has been estimated that both can be scoured by as much as 1.75 times the depth of flow

---

[1] This scheme is similar to a cycle on the Rivers Clyde and Manning flood-plains in Australia (Nanson, 1986).

Plate 19: Back channel ('by-pass canal') looking west. with point bar on left. See figure 'G' on figure

Plate 20: Tyne's gravel bed and south aspect of point bar to left, looking north-east. See 'H' and 'F' on figure

during a flood (Wolman and Leopold, 1957). The receding water forms a series of low ridges separated by troughs in a 'ridge and swale' surface (see plates 21, 22) across the point bar (Morisawa, 1985, 122-123). As for the back-channel, gradual deposition of finer material diminishes the rate of flow through it (Morisawa, 1985, 119), so that eventually most of the flow is confined within the main channel. Before the next flood, vertical accretion rebuilds the point bar (Nanson, 1986, 1472; see Stage 3).

The next flood re-inundates the point bar and back-channel. However, with the flood recession, scouring occurs to a greater extent through the back-channel than across the point bar. This is due to the build-up of heavy sediments throughout the year only on the point bar, and not in the back-channel, and because the water velocity flowing through the enclosed back-channel is greater than that receding over the point bar. Most importantly, sediments aggraded throughout the year, and from one year to the next on the point bar are sufficiently deep to allow considerable growth of vegetation such as trees and shrubs (see plates 20-22), which in turn protects the feature from aeolian erosion and reworking during flood recession (Petts and Foster, 1985, 188). Conversely, lesser aggradation in the back-channel supports less robust vegetation, so that scour has reduced the depth of the back-channel at Bywell to the original gravel river bed, and what sediments exist have been deposited only since the last flood recession. Vegetation is therefore minimal, and washed away by the next flood.

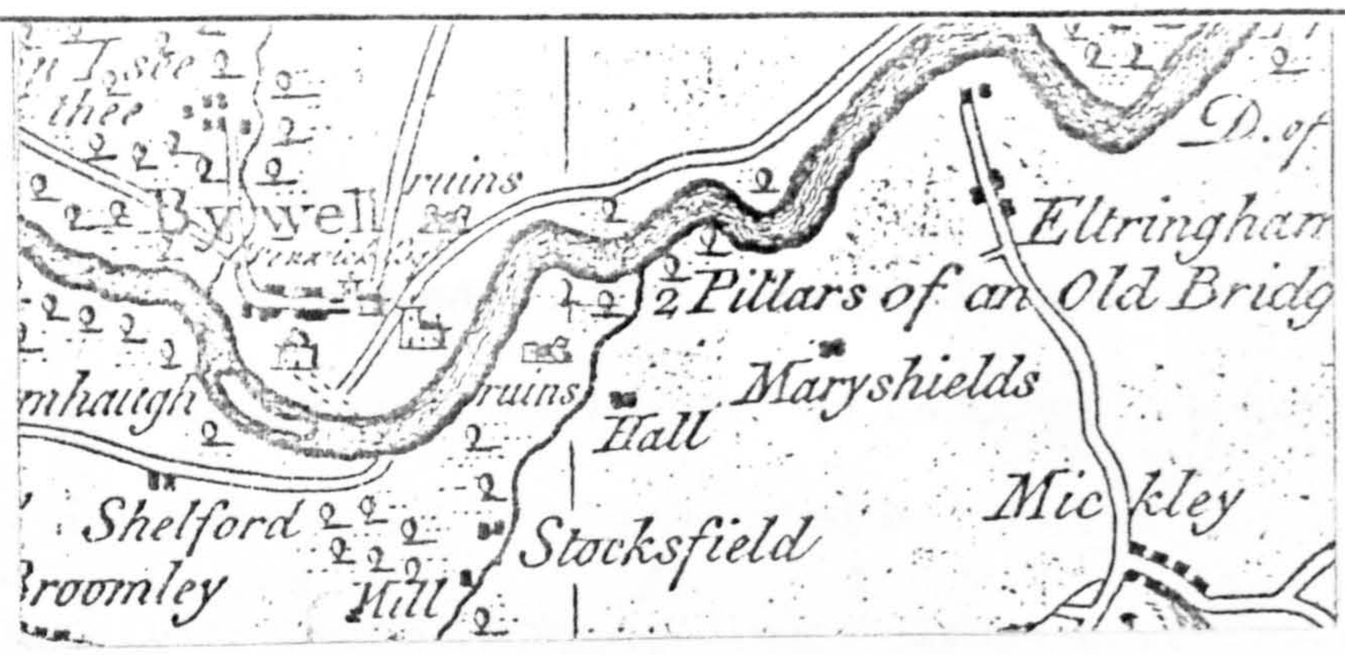


Fig 21: Map of Bywell, Armstrong, 1769

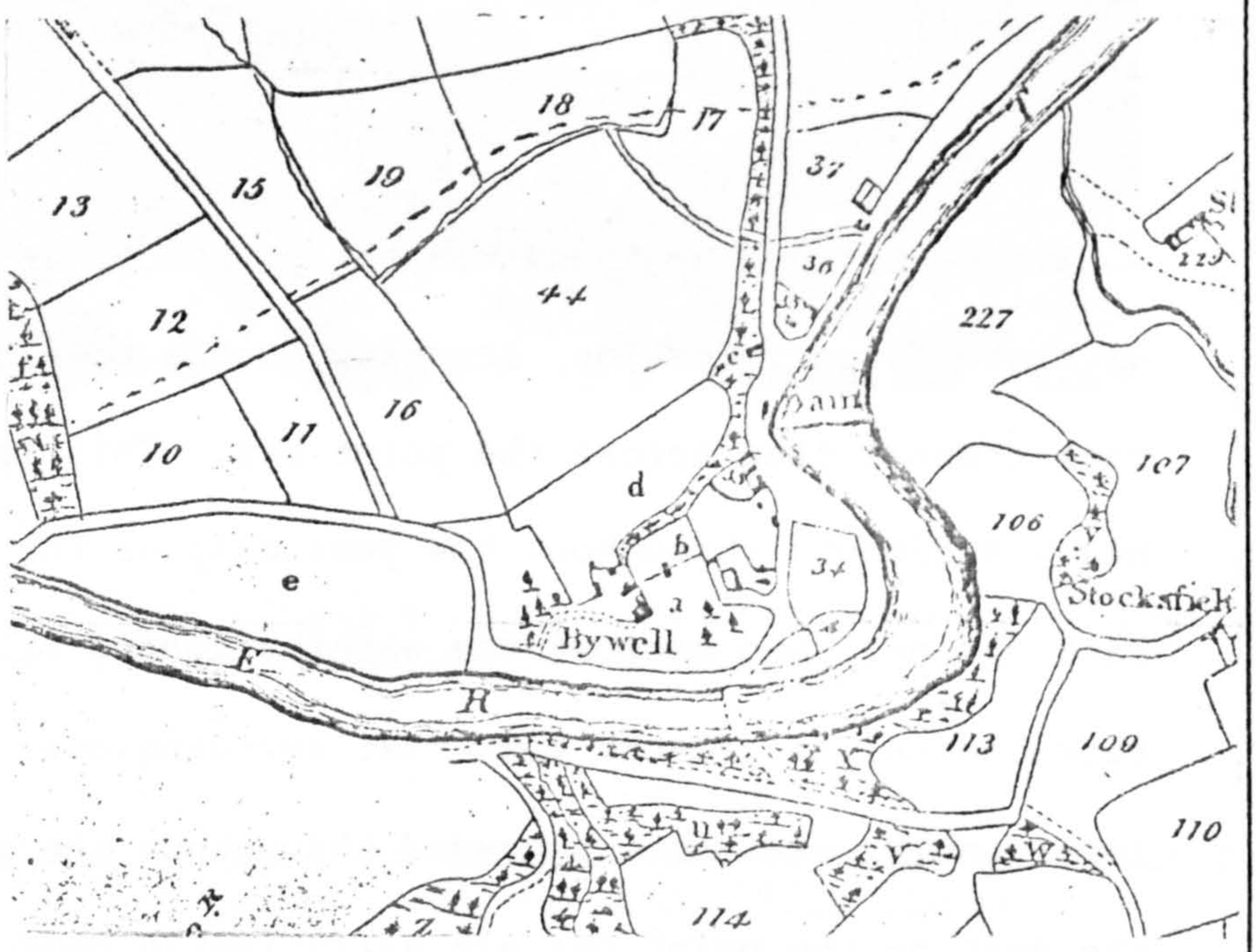
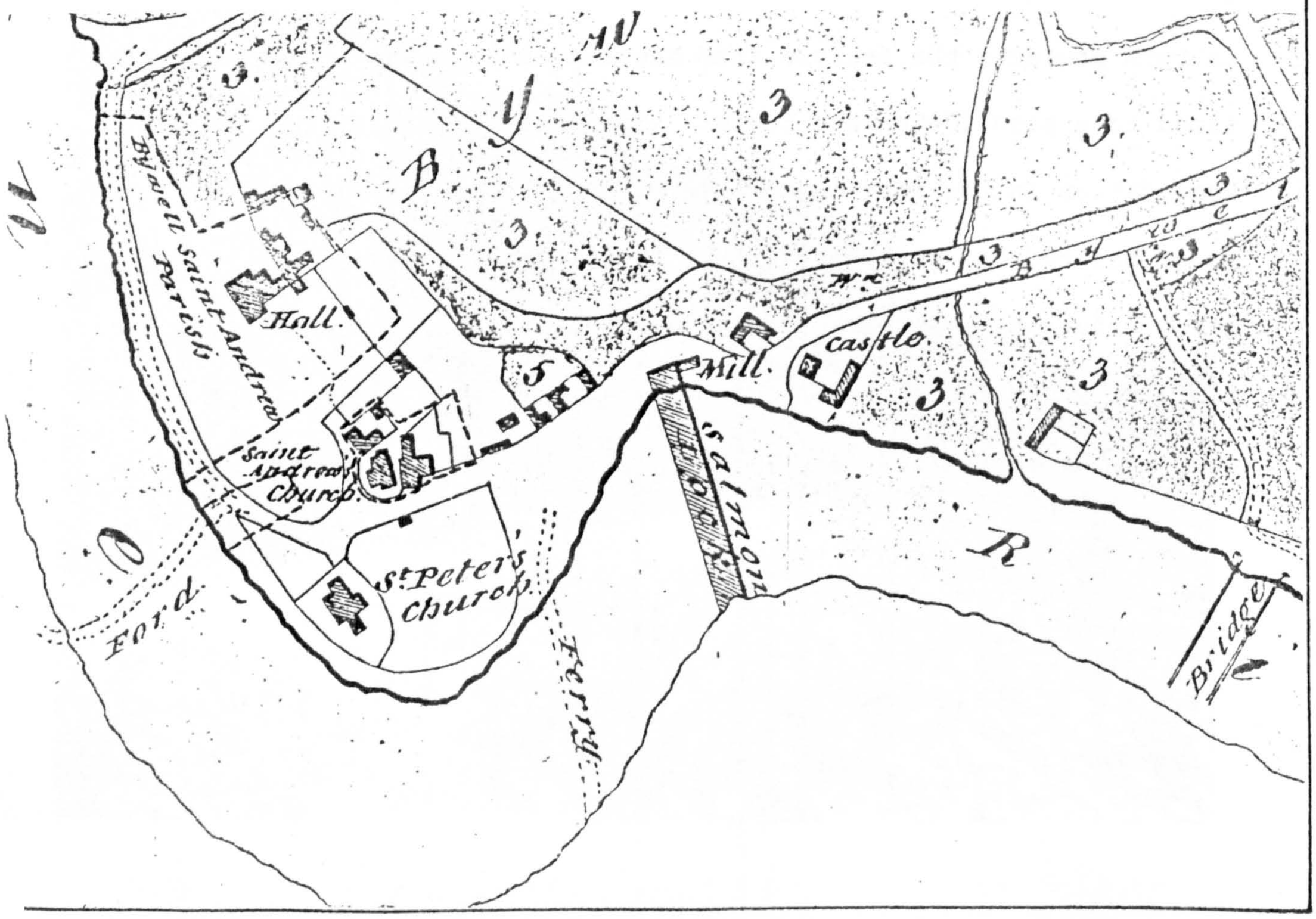


Fig 22: Bywell, 1819.

1817-1856



The result is that year by year, the back-channel incises at a faster rate than the point bar. Eventually, a very powerful, catastrophic flood will wash away the point bar (see Stage 4, figure 18), and the cycle will begin again with a flood plain stripped to the gravel bed.[1]

The 'by-pass canal', then, is a natural feature formed by the cyclical action of rising and receding annual flooding of the Tyne. The time frame for this process is difficult to estimate. However, Armstrong's map (1769; see figure 21) suggests that the point bar may have been in existence before the great flood of 1771. That this flood did not destroy the point bar suggests that it had been there long enough for the growth of sufficiently robust vegetation.

As this feature is not a 'by-pass canal', the structure at its upstream end is therefore not an 'entrance' to a Roman canal (see plate 18). In addition, its modern character,[2] together with the fact that in front sits a pool of stagnant, 'soapy' water, suggests that this structure represents rather a sewage facility serving Bywell Hall north-east of the Tyne's bank. Indeed, Bywell is not included on the County grid, so that raw sewage is discharged directly into the Tyne (pers comm Ian Christianson, hydro-engineer of Northumbria Water,

---

[1] However, such a flood might require destruction of the Catcleugh and/or Kielder reservoirs.

[2] This structure has a 4.5m face with .5m wing walls running 30 degrees from either side of the face 1.5m into the bank. The blocks are of concrete held together with an iron cage, and in front projects a small concrete block with a circular metal lid.

Plate 21: Channel in 'ridge and swale' surface of point bar at Bywell, looking east. See 'G' on figure

Plate 22: Outlet of channel in 'ridge and swale' over point bar, looking west. Note alluvial silts of point bar.

Hexham). Sewage draining throughout the year into the back-channel is washed with the annual flood through the back-channel into the Tyne's main channel.

Bridge

The case for a Roman bridge at Bywell rests upon evidence from etchings, historical accounts, and stones in the river. The etching evidence[1] suggesting the absence of a ramp is of little value. As discussed above (3.1.2), excavations at Chesters (Bidwell and Holbrook, 1989) prove that Roman bridge piers sometimes did in fact rest upon ramps, so that its absence does not necessarily denote a Roman bridge. In any event, it is far from certain that a ramp did not exist. First, it is difficult to rely on the etching evidence: artistic evidence must be applied with caution to scientifically-based problems, and the 1834 etching may be merely an artist's impression. Second, a ramp may have been below the water surface and out of the artist's view (Coupland, 1987; see plate 24), in which case it could be dateable to the Medieval period.

---

[1] The etching mentioned by Selkirk as dating to 1756 actually dates to 1774, and is entitled 'View of Bywell Bay', by William Bellers.

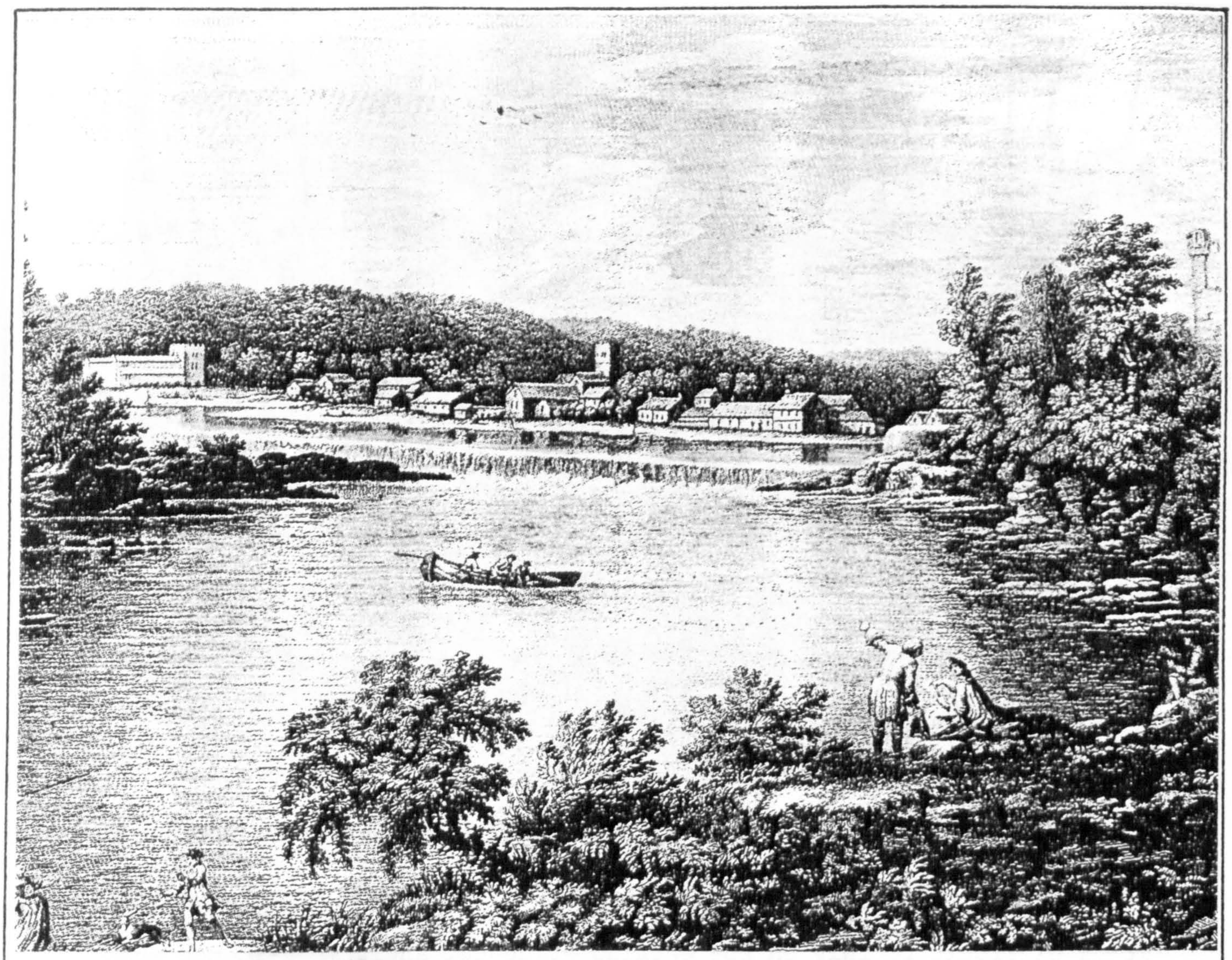
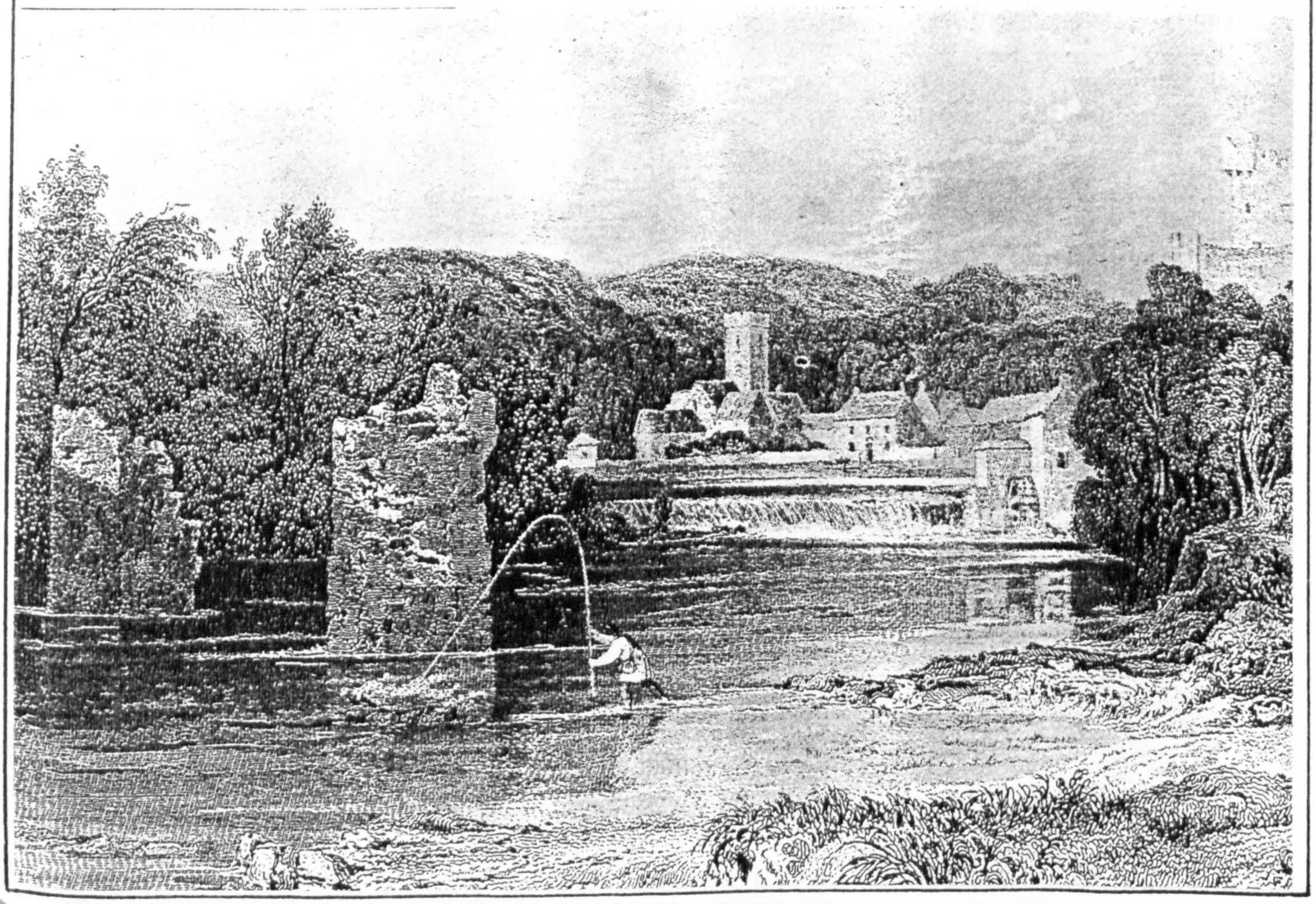


Plate 23: Engraving of Bywell Bay, William Bellers, 1774.

Plate 24: Engraving of Bywell Bay, by Thomas Allom, 1834.



In addition, it appears that the bridge at Bywell did in fact have arches consistent with Medieval bridges. In the earliest-known reference to this bridge:

> "ruines of arches of a stone bridge ouer tyne ryver att... longging to ye erle of westm[o]r[l]a[nd] 3 miles lower on the ryver then Corb[r]idge".
>
> John Leland, 1538, from Hearne, 1964

If the lewis-holed stones in the river were in fact cut in the Roman period, as with St Andrew's, the stone may have been brought from the ruin of the Corbridge Roman bridge and re-used in the Medieval bridge. Alternatively, the stone may have been cut in the post-Medieval period. A bridge may have been constructed on this site in the 16th century, replacing an earlier one destroyed before 1538 (see Leland's quote, above). That a new bridge was constructed in the 16th century is suggested by the vitality of Bywell at this time. Sixteenth century Bywell seems to have been an economic hub, with iron-mining, fishing, two churches, a market cross, mill, and castle, and a bridge would have been necessary, especially to facilitate the iron mining on either bank of the Tyne (Coupland, 1987, 72). The new bridge probably post-dates 1570, at which point a ferry is recorded to have been in operation.[1]

As discussed in Appendix F, the lewis-hole may have been re-introduced into Britain by the late 15th century. Therefore, construction of a new

---

[1] A survey of 1570 describes a wealthy widow named Alice Kent who operated the ferry (from Boddington, 1987).

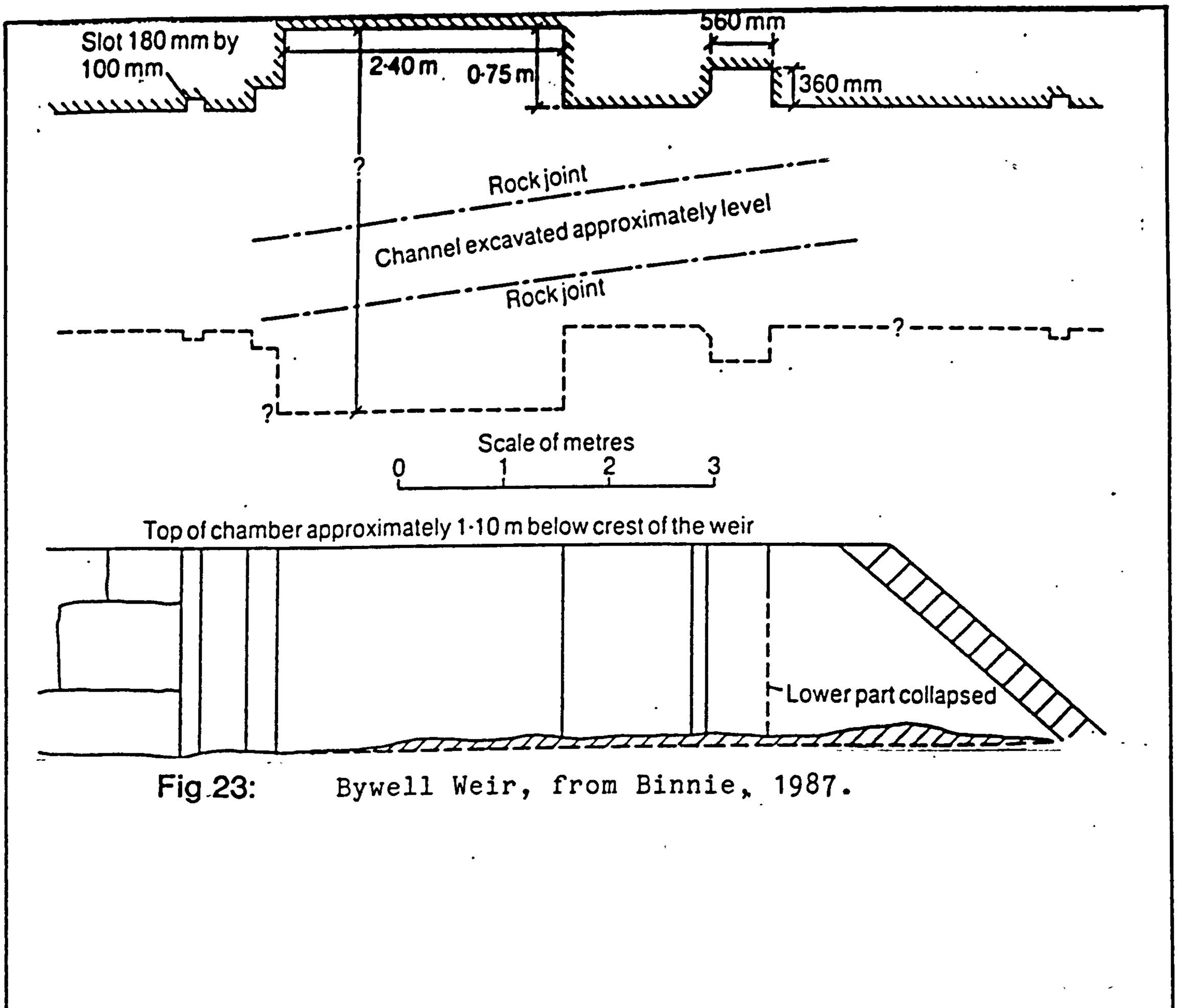


Fig 23: Bywell Weir, from Binnie, 1987.

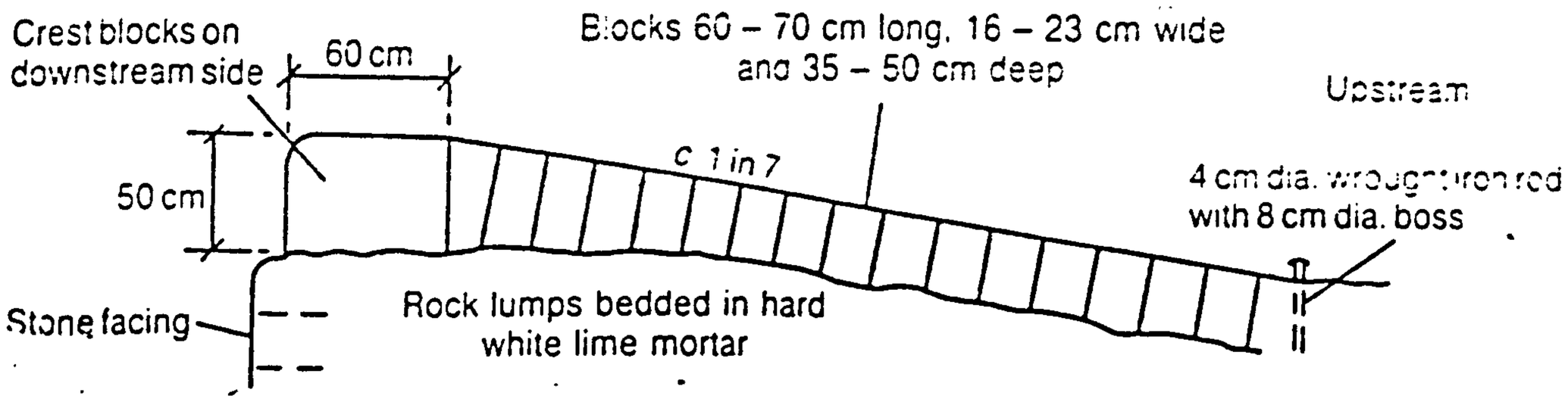


Fig 24: Bywell Weir, from Binnie, 1987.

bridge replacing the earlier destroyed before 1538 would have been after the introduction of the lewis-hole into Britain, so that these stones could have been cut in the post-Medieval, rather than Roman period.

A further alternative is that the lewis-holed stones in the river were cut originally for the post-1771 bridge, but were cast aside as unsatisfactory or surplus to need during bridge construction. Thus it is plausible that, far from being Roman, these stones are the product of post-Medieval craftsmanship (pers comm P T Bidwell).

Roman dam and pound-lock

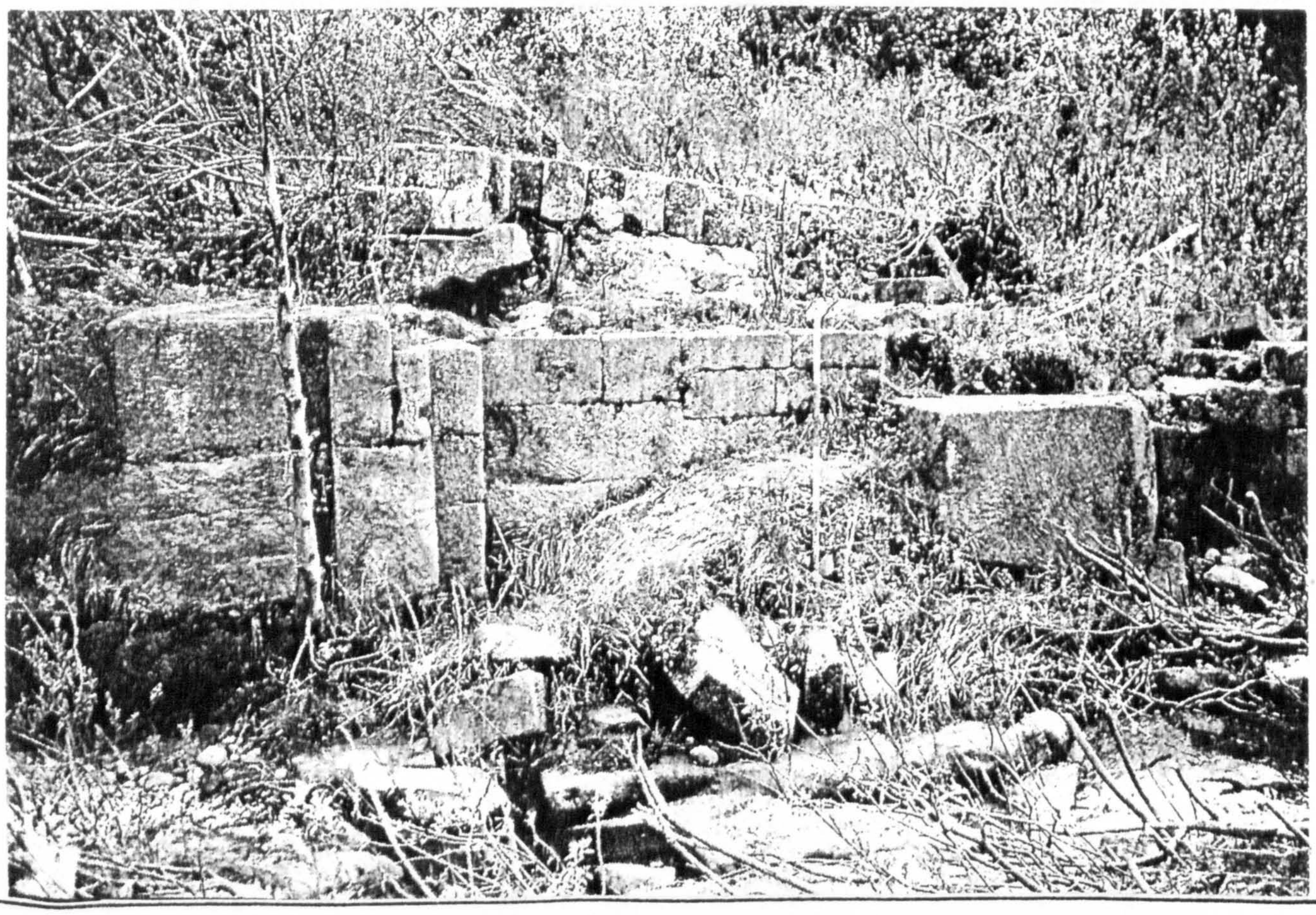
The visible remains of the dam do not appear to be of the Roman period. It contains Portland cement and many iron bolts and nuts secure a timber framework to chases (Bidwell and Holbrook, 1989, 154). In addition, the masonry and iron cramps are in excellent condition, especially when compared to remains at Chesters bridge abutments and the second bridge abutment at Piercebridge. This discrepancy is particularly suspicious when considering their respective contexts. Unlike at Chesters and Piercebridge, the stones and iron cramps at Bywell have not been buried under alluvia for millennia, but have been exposed to wind, rain, and the annual Tyne flood. This assessment is summed up by a civil engineer (from Binnie, 1987):

> "The whole appearance of the work is of a crispness and high quality ... The most likely date for the construction is in the early 19th century. It may very well have been a rebuilding of a previous weir, but there is no sign of an earlier work."

Plate: **25** (left) Bywell weir crest blocks and glacis, from Binnie, 1987.

(right) Bywell weir end blocks, from Binnie, 1987.

Plate **26** (below) Bywell weir masonry chamber, from Binnie, 1987.



In addition, evidence suggests that the weir was constructed in the 13-14th centuries. A document (see Johnson, Rev A, 1889, 108) refers to Alianor of Genevre (d.1310-11), who "possessed ... two locks for taking salmon at Bywell, and one acre of land abutting the dam". Another document (Johnson, Rev A, 1894, 297) suggests that the dam could not have been much earlier. It states that in the 12th century Walter de Bolbeck gave the White Canons "the appropriations ... of the churches of Harlow, Bywell, ... and twelve fishes for their table out of his fishery at Styford, in lieu of tithe-fishes". Binnie argues (1987, 21) that because Styford is only 5km from Bywell, and a fishery at Bywell is not known for certain, the dam with two salmon locks of 13th-14th century Bywell did not yet exist.

Furthermore, it appears that the Bywell dam was constructed for the purpose of fishing, and continued in that capacity thereafter.[1] Indeed, the feature described as a 'pound-lock' conforms very well with a fish-weir context: the 'guillotine' slots would have held at least two gates, and water released from the upper gate would have attracted salmon attempting to pass beyond the weir. Salmon would be trapped after both gates had been shut (Binnie, 1987).

---

[1] The dam is mentioned in an Inquisition of 1569 (Johnson, Rev A, 1889, 111): "to the barony of of Bywelle, in length three miles, which is a great commodity, and great plenty of salmon taken, and a dam or bay over the river, made strong of late for the preservation of the said fishing". In 1769, Wallis referred to "... a salmon weir... in the river". The decline of fishing along the Tyne in the 19th century eventually rendered the dam redundant, and its demolition in 1861 was probably a last attempt to restore the fishing.

4.2.3 Conclusion

No evidence securely dates the site or various Piercebridge formula components at Bywell to the Roman period. If Roman stone exists on the site, its quantity is not large enough to challenge the assertion that it was brought 10km downriver from Corbridge or from another Roman site. The 'canal/barge harbour' is, rather, a back-channel cut between the left bank and point bar to the south, formed by the scouring action of annual flood recession. The evidence supporting a Roman bridge ultimately rests upon the existence of lewis-holes, but it has been shown that these are not exclusively diagnostic of Roman period construction. Historical accounts suggesting construction of a dam at Bywell in the 13-14th centuries where one does not seem to have existed, as well as its tailor-made construction as a fish weir with 'traps', together with the lack of evidence for any other Roman period structure at Bywell suggests that the 'Roman dam' and 'pound-lock' belong instead to a Medieval and post-Medieval fish weir.

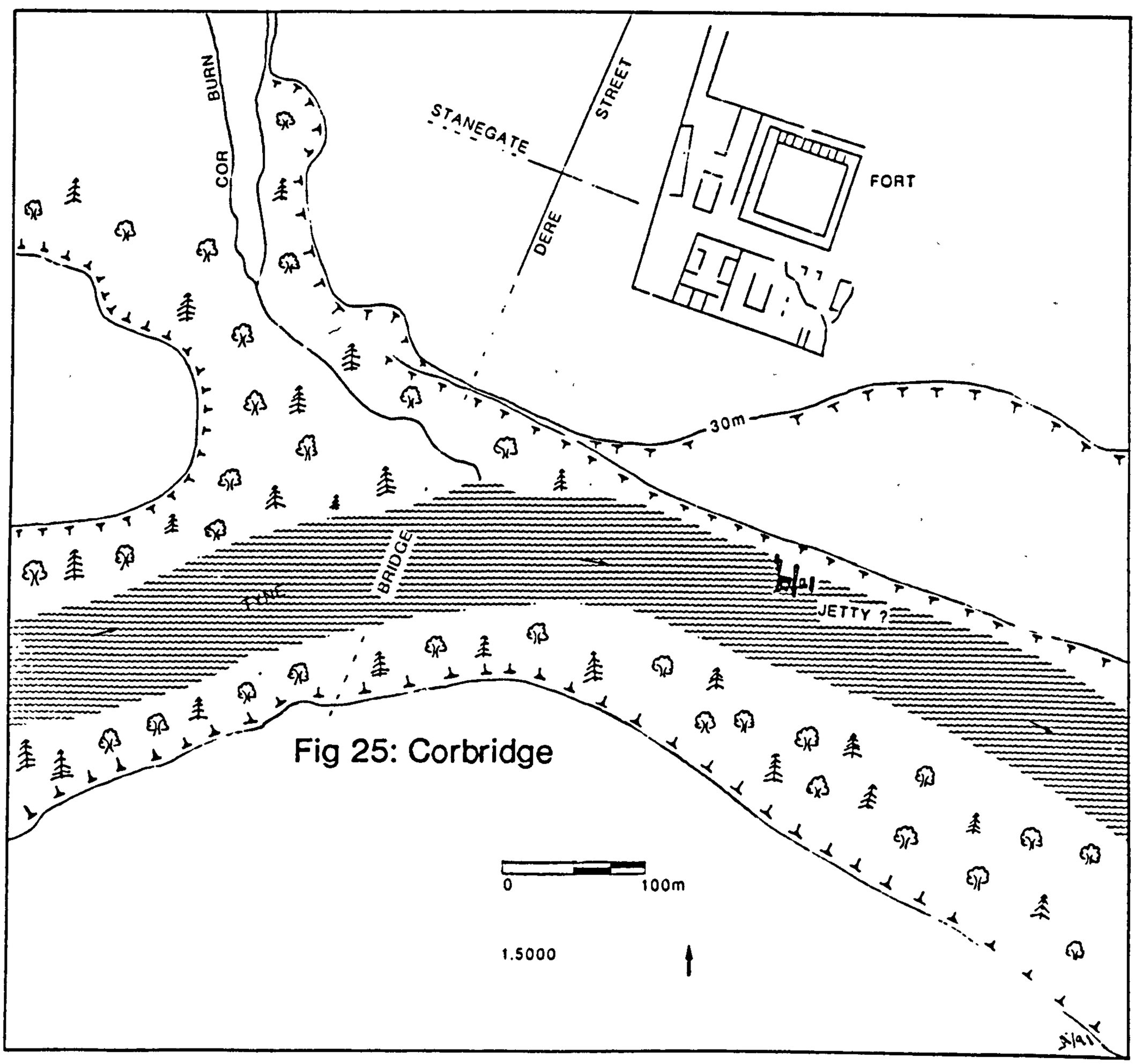


Fig 25: Corbridge

4.3 CORBRIDGE

About 10km up the River Tyne from Bywell, nine sets of rapids and 26km above the tidal limit near Wylam, and 6.2km downstream from the meeting of the North and South Tyne lies a Roman period site near the Medieval and modern town of Corbridge, Northumberland (see figure 25). After the abandonment of the Agricolan fort site at Red House (Daniels, 1959; Hanson et al, 1979), a new fort was constructed on the edge of the south-facing scarp of the river terrace, overlooking the bridging point. [1] According to the Piercebridge formula (Selkirk, 1983, 101; forthcoming), provisions would have been barged from South Shields to a 'jetty' below the forts of various periods at Corbridge.

4.3.1 Evidence Supporting the Piercebridge formula

> "The fascinating implications of the Roman date for the jetty are that we now know that Roman barges operated in the Corbridge area."
>
> Selkirk, forthcoming, 3

Timber resembling that found at the Roman port of London, as well as Roman period stone have been found on the river bed below the fort

---

[1] The first phase of this fort, perhaps 5.2 ha in area, was reduced to 2 ha before 103 (Bishop and Dore, 1988, 129-131). After destruction by fire, a new fort 2.7 ha in area was built ca 105 (Richmond and Gillam, 1955, 230-1), and reconstructed in the Hadrianic (phase III) and probably early Antonine periods (phase IV: Bishop and Dore, 1988, 140), with an additional phase in ca 158. By ca 163, the focus of activity at Corbridge seems to have shifted to the civilian community.

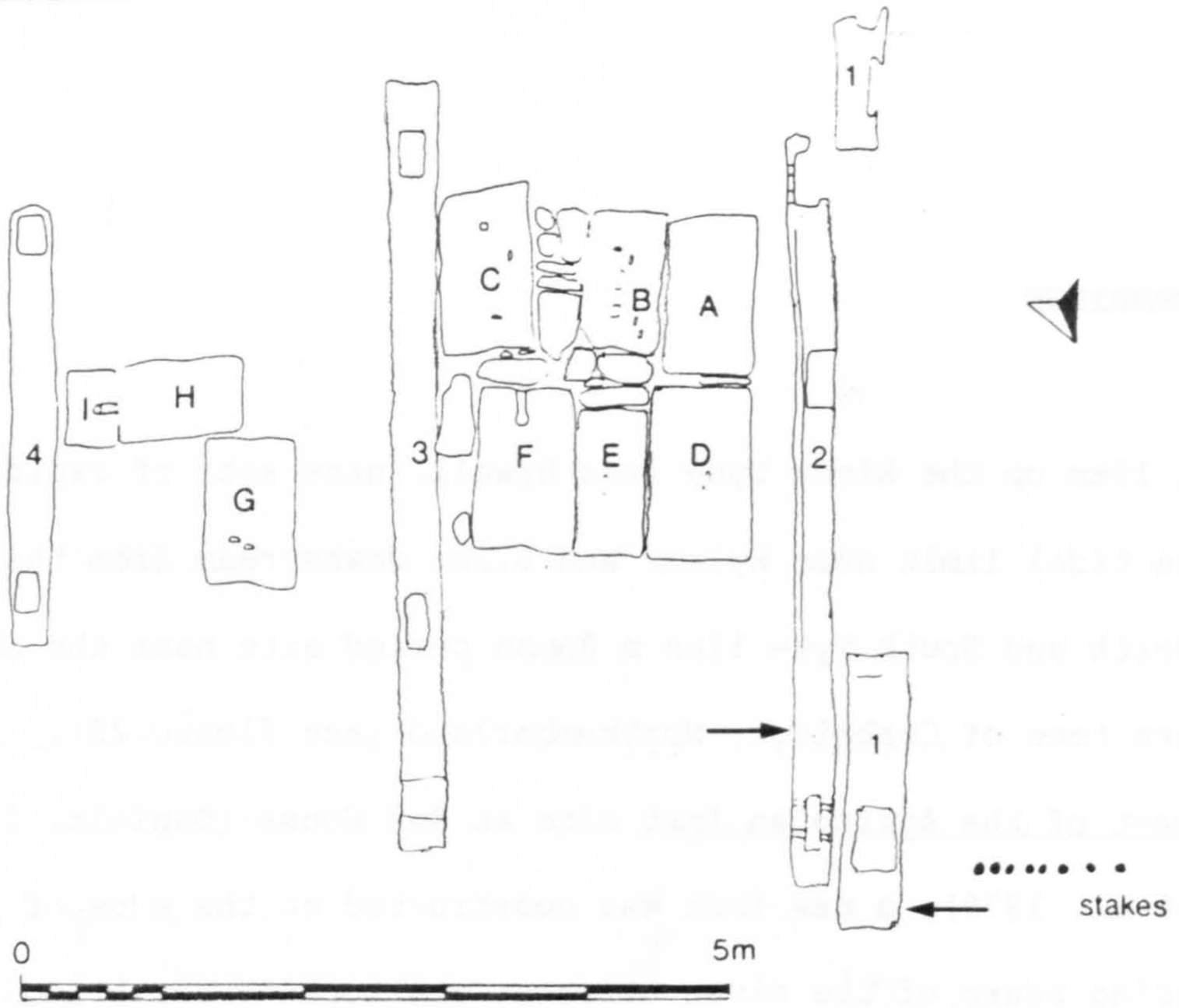
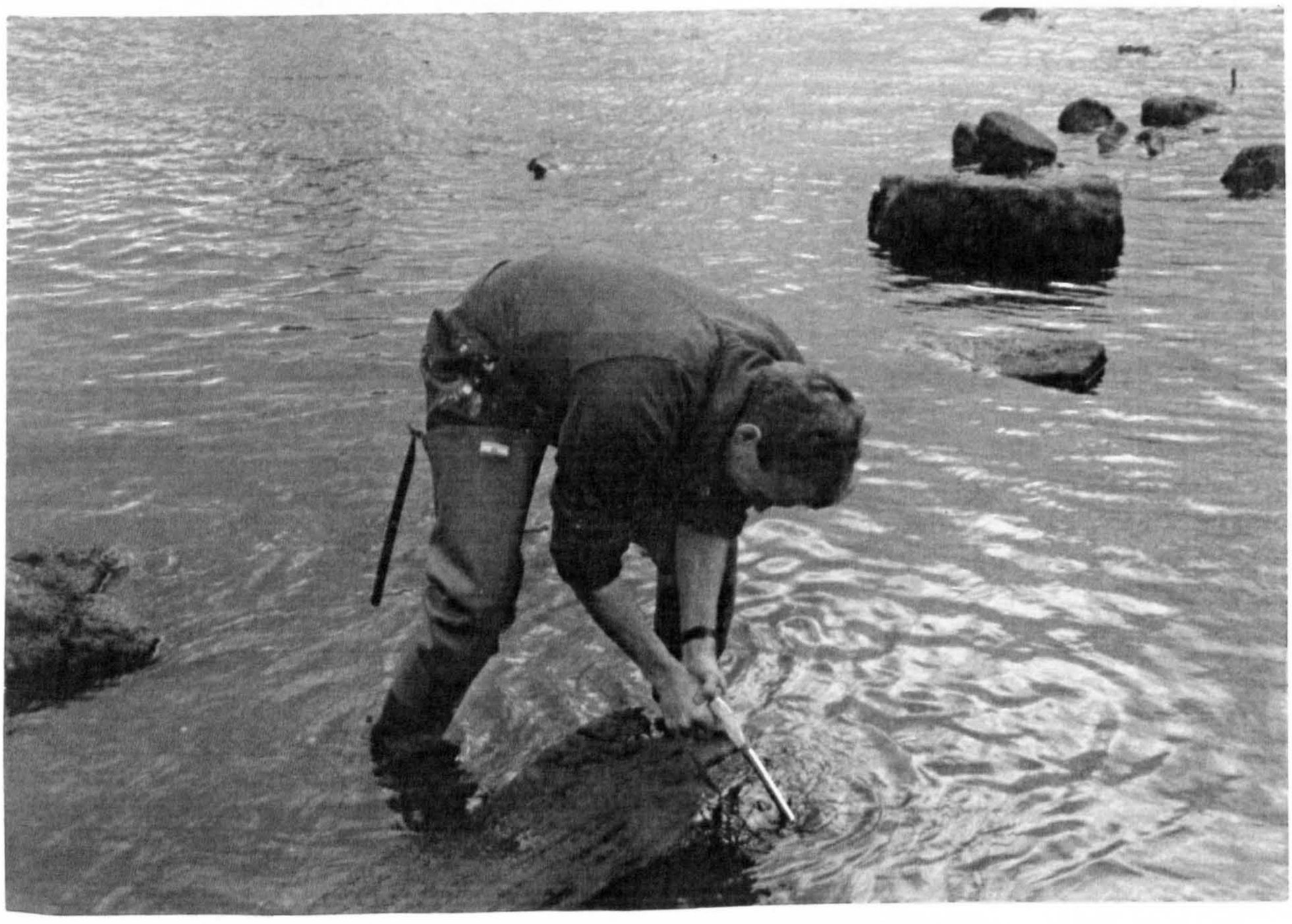


Fig 26: 'Roman jetty', from Bidwell and Holbrook, 1989, 106.

Plate 27: Extraction of timber sample for radio-carbon dating from structures marked ' → ' above.



(Selkirk, forthcoming). In addition, a Constantinian coin was found wedged between two of the rectangular paving stones, as well as samian pottery in the bank-side just above the 'jetty' (ibid.). If the accepted theory of river movement is correct, which states that the river has moved south of the Roman period river channel, this pottery would have been "deposited in thin air above the centre of the river two thousand years ago" (ibid.).

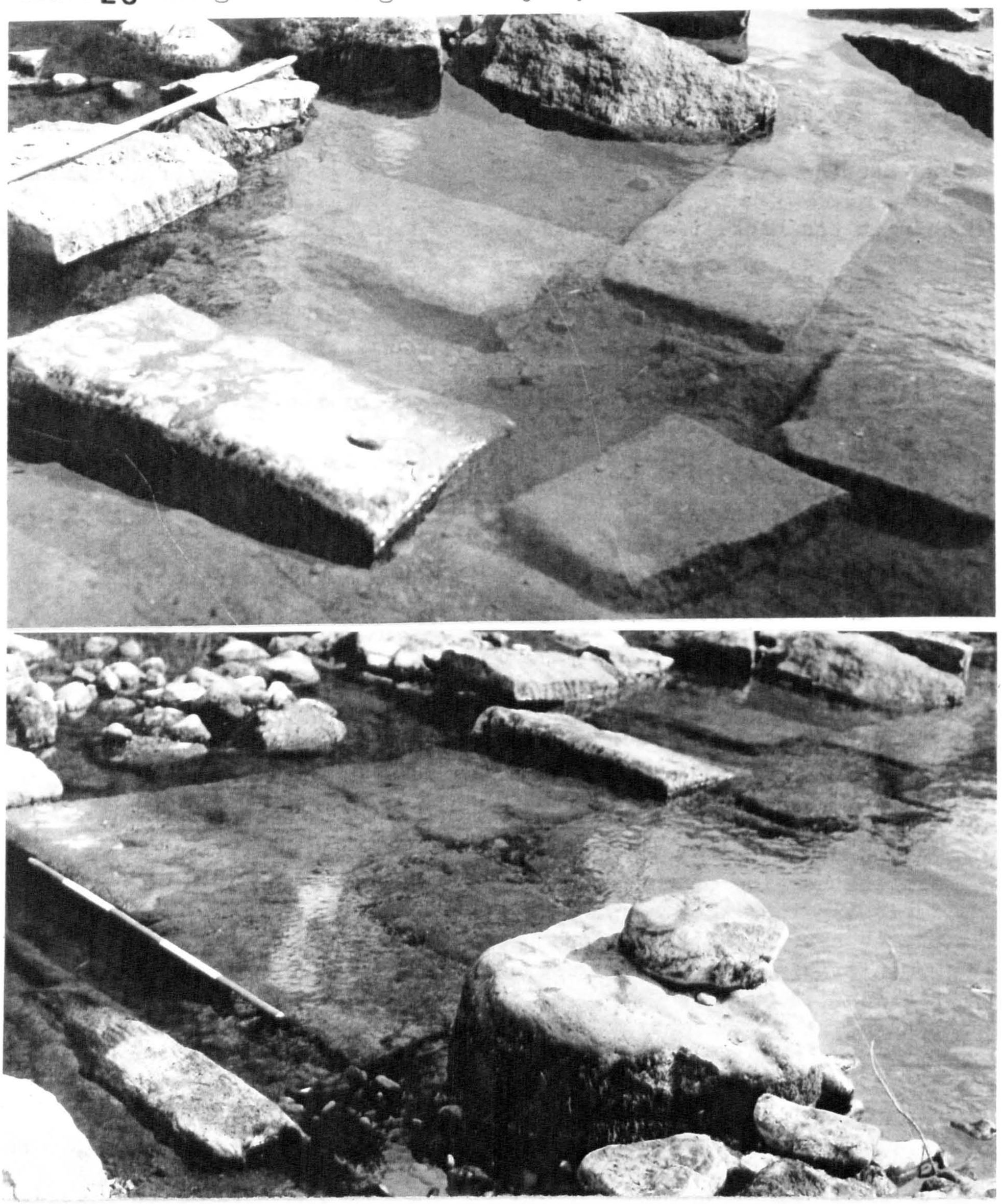
4.3.2 Evidence Refuting the Piercebridge formula

On the other hand, this structure has long been considered Medieval, made with re-used Roman stone. After the 1907 Corstopitum excavations, Forster (in Woolley, 1907, 180) wrote:

> "About eighty yards [24.6m] below the line of the Roman bridge are the remains of what appears to be a Medieval quay or ferry-landing: they consist of a platform with a river face of thirty seven feet [10.1m] composed of large stones, evidently of Roman origin, with four massive timbers about a foot square in station [.305m sq], one at either end of the platform, and two running at approximately equal intervals through the centre;"

The timbers lie in three parallel lines, running perpendicular to the river course (see figure 25, 26; plate 28). On the west, they measure 6.45m by .4m wide, and 5.2m long by .3m wide, and the two rows on the east lie 2.4m apart (Bidwell and Holbrook, 1989, 106). The timbers have holes cut into their surfaces to accommodate uprights, and several of the holes were aligned between the two parallel rows of timbers (ibid.). Although the holes recall mortises used by Roman craftsmen, mortise and tenon joints also were used in the Medieval period: Milne (1979, 20)

Plate 28 Paving in Corbridge 'Roman jetty'. Courtesy of R. Selkirk.



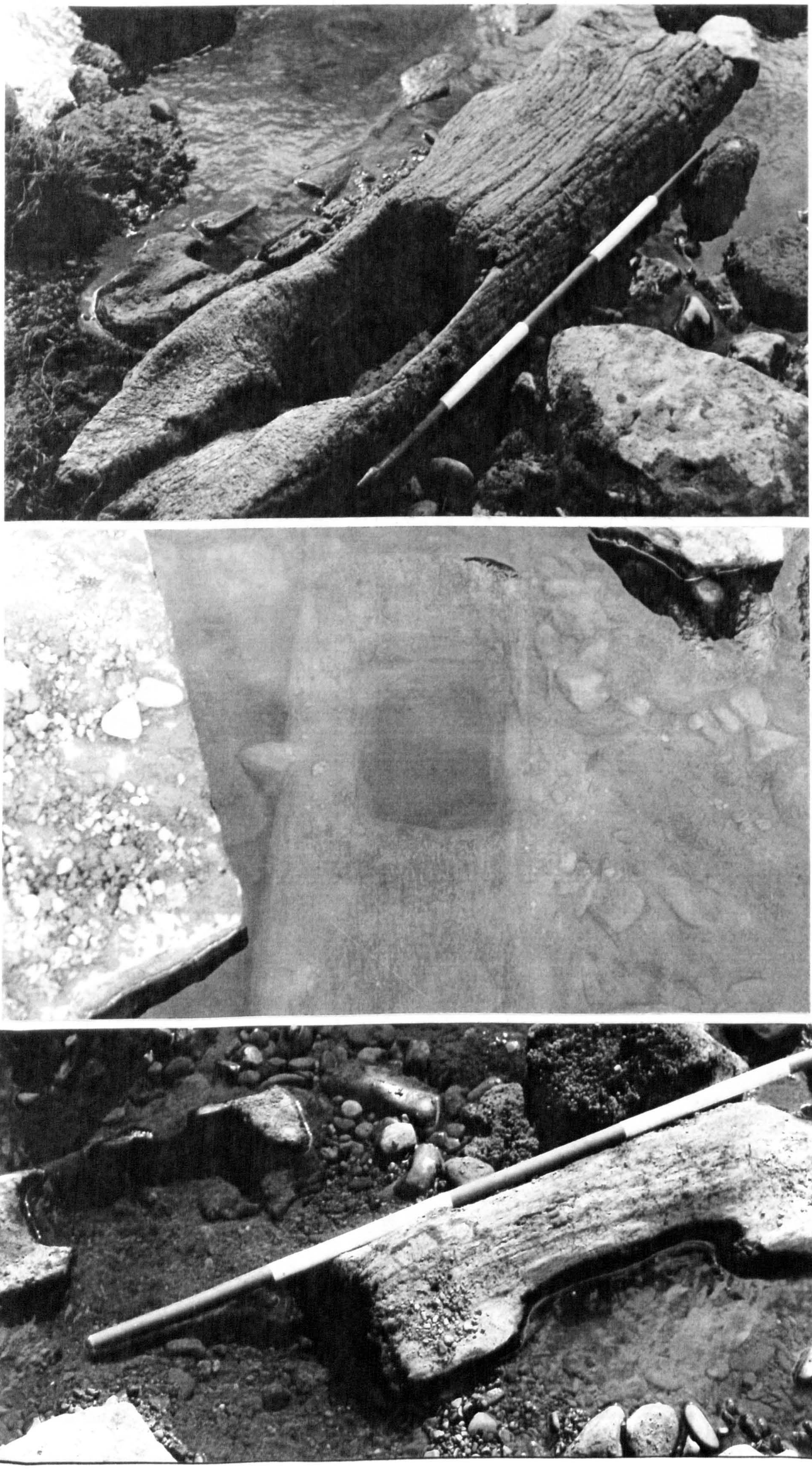
Timber in Corbridge 'Roman jetty'. Courtesy of R.Selkirk.

argues that mortise and tenon joints are "basic to [Medieval] carpentry and joinery ... commonly used to join the feet of the posts to the principal base plates". The timber could have been used just as easily at any time during the Medieval rather than Roman period.

Two samples were cut from two separate timbers lying below the water's surface (see plate 29), and submitted in May, 1991 for radio-carbon treatment. CB1 was dated to 1190 BP +/- 70 (Beta-37206), or AD 760 +/- 70, and CB2 to 1040 BP +/- 60 (Beta-44425), or AD 910 +/-60. The earlier date of the second (and later) timber represents a terminus post quem of AD 850 for the construction of this structure. Therefore, these timbers were laid down at least 440 years after the traditional date of the end of Roman Britain - 410.

Between the rows of timbers are quantities of Roman stone, with cobbles and fragments of sandstone packed between them (Bidwell and Holbrook, 1989, 106; see figure 26, plate 27). As the stones abut the timbers, it is most likely that the timbers were laid down first, followed by the setting of the stones. Indeed, it would have been very difficult to have wedged timbers in perfectly parallel lines between stones already placed under the water's surface. Therefore, the date at which the timbers were laid into the river represents a terminus post quem for the entire structure, so that the stones would have been set in the river after 850.

Plate 29 Timber from Corbridge 'Roman jetty'. Courtesy of R. Selkirk. Note ' mortise holes'.



As for the Roman character of the stones, as at Bywell, the presence of Roman stone on a site does not indicate necessarily a Roman period structure. Indeed, the stones were worked to perform various functions: three stones have lewis holes, another three have dowel holes, one a bar clamp slot, and three have crowbar slots, and it has been argued that they once belonged to the superstructure of the Roman bridge at Corbridge (Bidwell and Holbrook, 1989, 106). That the stones in question were taken from that structure is supported by the evidence of stone from the same bridge used elsewhere. Many were used to build the casing for the water wheel at Dilston mill, about 2km south of Corbridge. In addition, at least some of the stonework in Hexham Abbey must have come from the bridge at Corbridge: not only do inscriptions (RIB 1151 and 1172) attest to the use of Roman stone from Corbridge, but opera quadrata have been found in the crypt and the church above, and the bridge is the only structure at Corbridge to use such stones (Bidwell and Holbrook, 1989). Therefore, it is likely that the Roman bridge at Corbridge provided a convenient source of worked stone for the construction of the 'jetty', and that the latter was built after the Roman bridge had fallen into ruin.

The 'jetty' has also been dated to the Roman period on the assumption that the coin and samian pottery were deposited within and near the structure in the Roman period. However, the use of these artefacts as dating evidence is problematic, since it is far from certain that the artefacts were deposited in a Roman period context.

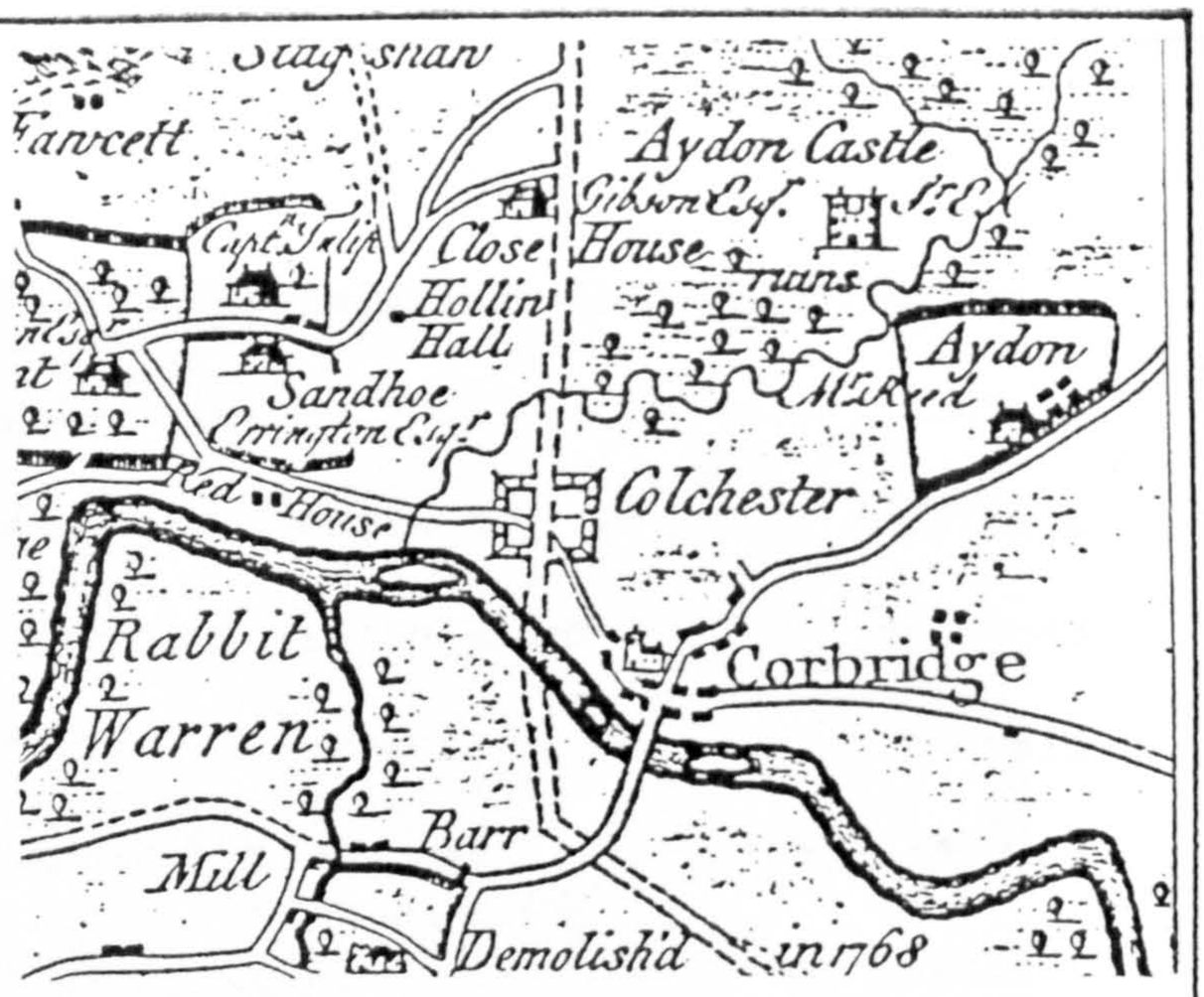


Fig 27: Corbridge

Armstrong, 1769.

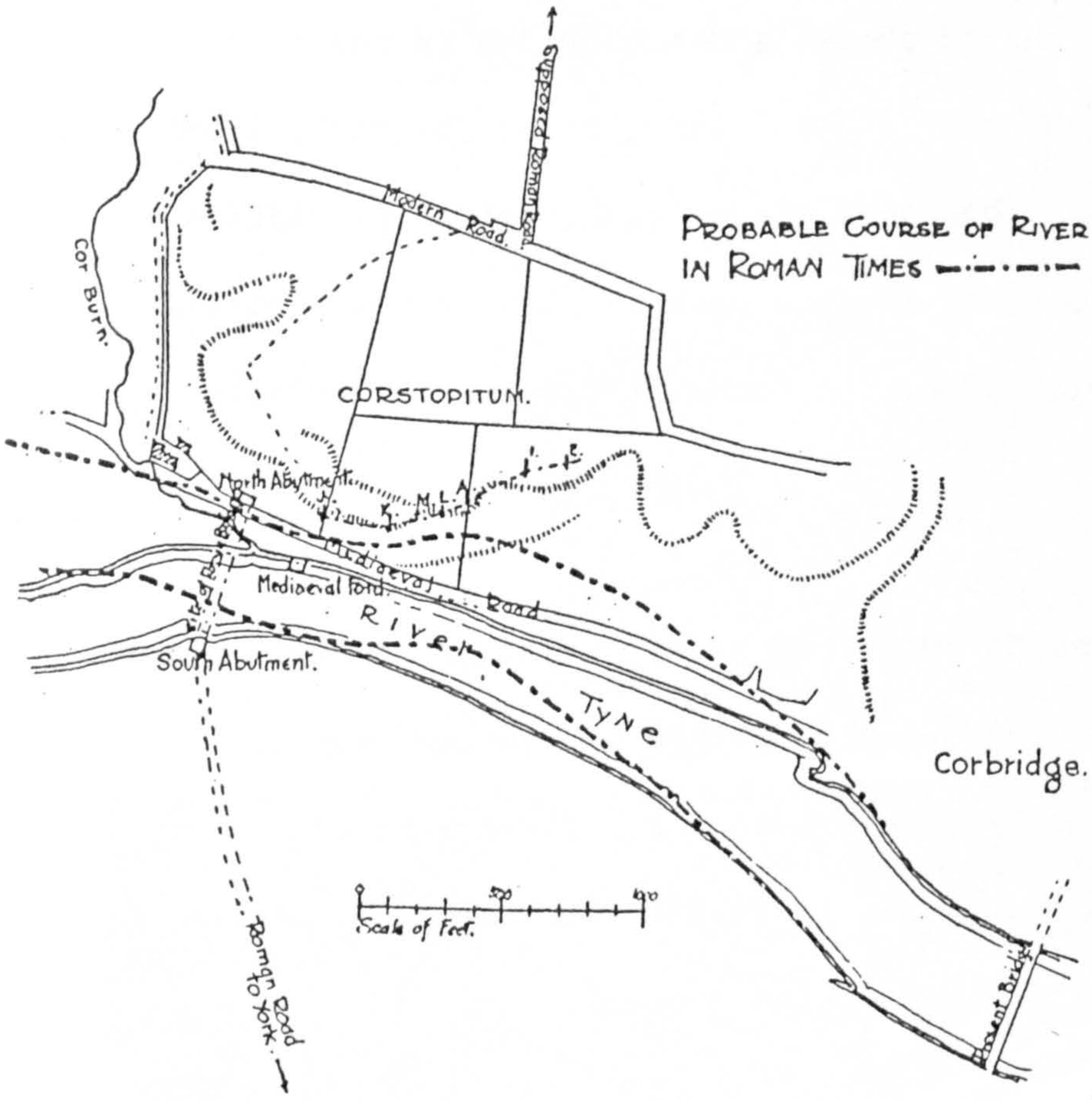


Fig 28: Corbridge

Woolley, 1907.

Contrary to what has been suggested (Selkirk, 1986), the river has indeed moved to a great extent across the flood plain below Corbridge. As discussed above in the Bywell section, the Tyne at this point takes the full force of the flood waters from the North Tyne and South Tyne, and these discharges would have been even greater before reservoirs were constructed upriver. The annual overbank flooding and meandering of such a volatile and flood-prone river would have re-distributed much material across the river bed from one year to the next.

That the river has moved since the Roman period is also suggested by the orientation of the Roman bridge to the modern river course. In 1908, after finding the south-east corner of the southern abutment in the river 9.3m from the south bank, Forster calculated (in Woolley, 1907, 177-9) that the projected line of this abutment traversed the modern river course at an oblique angle. He concluded that the river must have changed course, as the heavy spate of the Tyne would have rendered very tenuous a bridge constructed askew across its width and current (see figure 28). This radical change in course alone could have been responsible for the distribution of the artefacts in the vicinity of the 'jetty'.

Therefore, at any point since the Roman period, the Constantinian coin and samian pottery could have been washed from either bank below the fort and deposited near the 'jetty': given the high degree of river action, a Roman period context for the deposition of these artefacts is unlikely.

4.3.3 Conclusion

No evidence proves construction of Piercebridge formula components at Corbridge. The 'jetty' contains timber radio-carbon dated to ca 850, well after the Roman period. The structure contains re-used Roman period stone, most likely robbed from the superstructure of the nearby ruined Roman bridge. The samian pottery and coin found in the vicinity can be explained as transient finds which proliferate around important Roman sites such as Corbridge: the distribution of finds across the river bed would have been facilitated by the lateral movement of the river since the Roman period.

The minimum date of 850 for the timbers in the 'jetty' dismisses the possibility that this structure was used for Roman period river navigation. Rather, it was constructed at a period half-way between the end of the Roman period and the construction of a new bridge in 1236. Given that no evidence exists for a bridge in this intervening period, this structure may have served as a ferry-landing after the Roman bridge had collapsed, and before the 13th century bridge was constructed.

In addition, this structure may have functioned as a quay for craft navigating the Tyne to a certain extent. Indeed, Roman stone robbed from the ruins of the Roman bridge and occupation at Corbridge and used to construct this 'quay' may have been collected at this point and transported downriver on barges or rafts for construction of Medieval buildings at Corbridge and Bywell.

4.4 VINDOLANDA

The Roman fort of Vindolanda[1] lies below Barcombe Crag, at a point along the Stanegate where it crosses the Chesterhope Burn, and at modern Chesterholm, Northumberland. Although still very complex, excavations throughout the 1970's and 1980's have elucidated somewhat the progression of timber and stone forts on the site (see Birley, R E, 1989; Bidwell, 1989b). A military occupation at this site stretches from the Flavian period to perhaps the 5th century (Daniels, 1978, 158).

According to the Piercebridge formula, Vindolanda, as well as forts along the Wall immediately to the north in Area 2 - Carrawburgh, Housesteads, and Great Chesters, would have been supplied first by barges navigating the Tyne and South Tyne, and second by carts driven to each respective fort (Selkirk, 1983, 101). None of the Piercebridge formula components on the Tyne so far examined necessarily date from the Roman period, while potential components further along the Tyne above Corbridge, or along any stretch of the South Tyne are not listed in The Piercebridge Formula. Therefore, an analysis of Piercebridge formula supply to these forts cannot devolve upon an examination of proposed Piercebridge formula components in the rivers of Area 2 beyond Corbridge. However, in lieu of such components, certain evidence recovered at Vindolanda argues against Piercebridge formula supply.

---

[1] This site is recorded as such on an inscription found in the vicus, as well as in the Notitia, which lists the Fourth Cohort of Gauls as its garrison.

4.4.1 Evidence Refuting the Piercebridge formula

The Vindolanda Writing Tablets

During excavations from 1973-76, remarkably well-preserved tablets[1] were found in a deep trench outside the south-west corner of the 3rd century fort, which penetrated to the timber fort layers. Made of thin pieces (never more than 2mm) of predominantly alder and birch and generally rectangular in shape, the tablets were inscribed with ink made from carbon black, gum and water - a mixture common to papyri. The tablets from layers 10/8 came from a rubbish dump near the fabrica, while Layer 6 and 5 comprised the occupation debris of what was a barracks building (Bowman and Thomas, 1983, 20).

A large proportion of tablets found in 1985-6 excavations were recovered on the eastern side of the south section of the via principalis, and some within the praetorium (Bowman and Thomas, 1987), as well as the Period I ditch and the floors and pits of the timber buildings. These contained in excess of one thousand stylus and ink-leaf documents and correspondence (Birley, R E, 1989, 46). Tablets recovered in 1987-88 excavations have yet to be fully published. In total, the

---

[1] Their excellent state of preservation is owed to clay compactions between the levels of occupation, creating pockets of anaerobic conditions in which the tablets lay (Bowman and Thomas, 1983). In addition, tannis produced by organic materials as well as vivianite or iron phosphate caused by the accumulation of bones of horses, oxen, pig and duck, enhanced the preservative factors (ibid.).

tablets range in dates from AD 90-100 to 120, were written by many hands and generally comprise official documents and correspondence.

At no point throughout the entire corpus of the tablets so far published is mention made of shipment/supply along the Tyne and South Tyne, or by rivers in general:

> "In the period covered by our written records, I can find no hint that supplies were ever sent or received by ship or barge..."
>
> pers comm R E Birley

This constrasts dramatically with the frequent mention made of overland transport. Indeed, tablets often mention wagons, oxen, horses, and road-building, as well as communications with other forts in northern Britain.

Wagon Transport. One letter (Inv. 85/103)[1] attests to the transport of stone by wagon on a fairly large scale (Bowman and Thomas, 1987, 129), perhaps intended for construction of a bath-house or some such installation on the Stanegate road (ibid.). Another letter (Inv. 85/121, 86/447) attests to the dispatch of wagons to a praefectus named Vocusius Africanus, and the use of timber (ibid.). Further, a tablet (Inv. no. 85/51) records the dispatch of goods, predominantly wagon parts, from

---

[1] The convention for defining specific Vindolanda writing tablets has changed over successive publications. The full reference includes Doc. (Document number), Inv. (Invoice number), and Layer number. However, some publications include only the Invoice number. All references in this thesis follow the convention set down in each specific publication of the tablets.

Vindolanda (ibid., 141):

"Metto[?] to his Advectus[?] very many greetings. I have sent you wood through the agency of Saco:

hubs:	number, 34
axles for carts:	number, 48
therein an axle turned on the lathe:	number, 1
spokes:	number, 300+
planks[?] for a bed:	number, 25+
seats:	number, [ ] 8
knots[?]	number, ...

...

May you fare well, brother."

Such epigraphic evidence compliments well the archaeological evidence for carts at Newstead,[1] and wheel ruts at many forts along Hadrian's Wall, such as at Knag Burn Gate at Housesteads (below, 6.2.3).

Supply from the South. Recovered in the turf filling above the demolished remains of the fabrica and most likely belonging to Period IV (AD 105-125), one tablet (Inv. 88/946) sheds much light not only on long distance overland transport to Vindolanda, but also much else about transport in general. Although the address (vindol) on the reverse is somewhat problematical,[2] it is nevertheless argued (Bowman, Thomas, and Adams, 1990, 34-35) that the letter was to be delivered to another

---

[1] "Two wheels, almost entire, were found in Pit XXIII, and a third in Pit LXX. Spokes of wheels or other wooden fragments came from Pits LIV, LXV, and LXXXII, while among the hoard of iron objects in Pit XVII were twenty-three hub-rims, three hub-linings and some broken fragments. A portion of a wheel tyre in process of being manufactured into something else was taken from the same receptacle. A rusted tyre came from the ditch of the South Annexe, and a portion of another from Pit LVII at the Baths" (Curle, 1911, 292-4).

[2] Indeed, if sent from Vindolanda, it is curious why it records the return address rather than the destination.

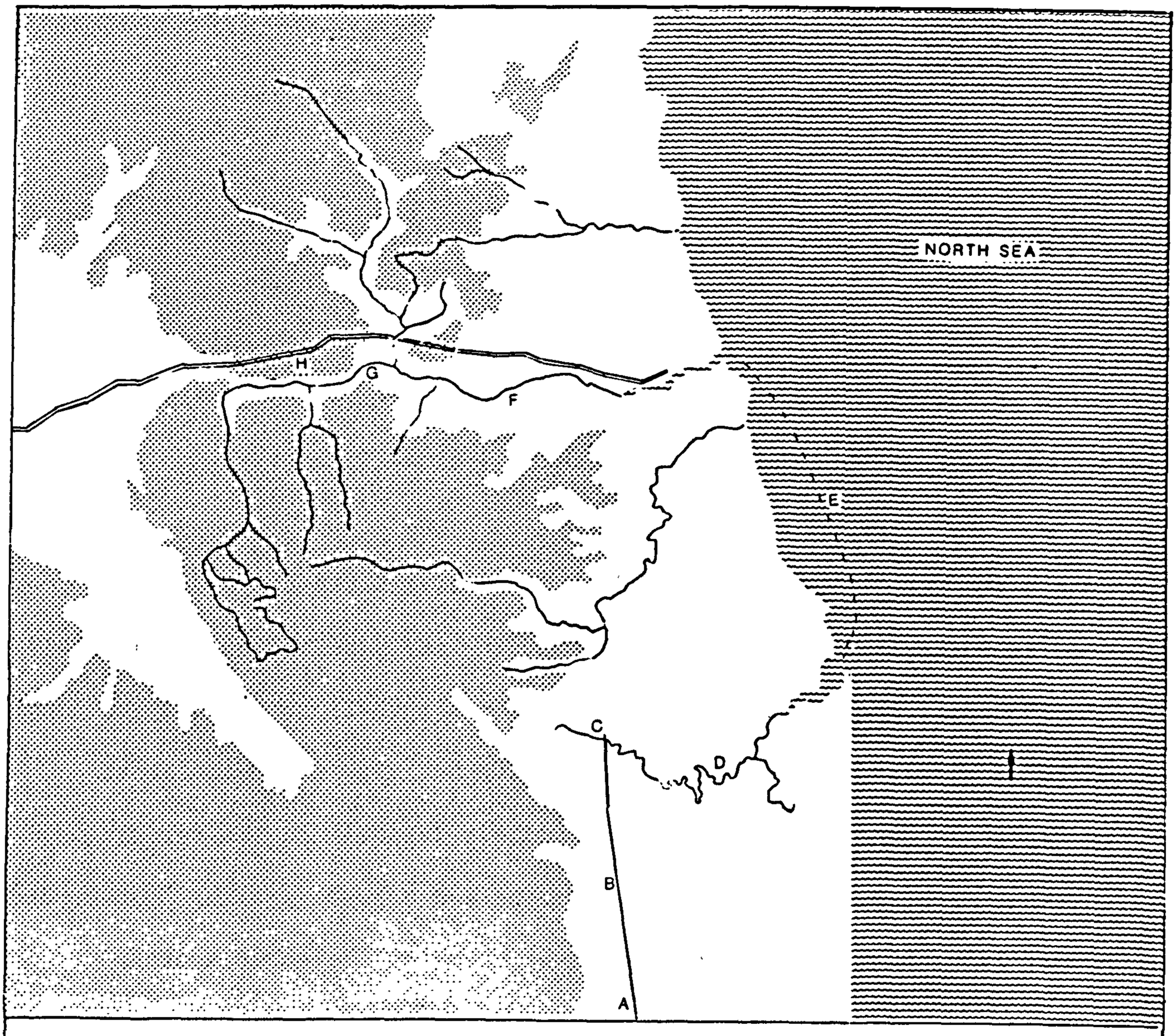


Fig 29: Catterick to Vindolanda via river system

A CATTERICK

B DERE STREET

C PIERCEBRIDGE FORT

D TEES

E SEA JOURNEY

F TYNE

G SOUTH TYNE

H VINDOLANDA

0 30km

1:1,000,000

destination, but never sent from Vindolanda.

> "Octavius to his brother Candidus, greetings. The hundred pounds of sinew from Marinus - I will settle up. From the time when you wrote to me about this matter, he has not even mentioned it to me. I have several times written to you that I have bought about five thousand modii of ears of grain, on account of which I need cash. Unless you send me some cash, at least five hundred denarii, the result will be that I shall lose what I have laid out as a deposit, about three hundred denarii, and I shall be embarassed. So, I ask you, send me some cash as soon as possible. The hides which you write are at Cataractonium - write that they be given to me and the wagon about which you write. And write to me what is with that wagon. I would have already collected them except that I did not care to injure the animals while the roads are bad. See with Tertius about the 8 1/2 denarii which he received from Fatalis. He has not credited them to my account. Know that I have completed the 170 hides and I have 111 (?) modii of threshed bracis. Make sure that you send me some cash so that I may have some ears of grain on the threshing floor. Moreover, I have already finished threshing all that I have. A messmate of our friend Frontius has been here. He was wanting me to allocate (?) him hides and that being so, was ready to give cash. I told him I would give him hides by the Kalends of March. He decided that he would come on the Ides of January. He did not turn up nor did he take any trouble to obtain them since he had hides. If he had given the cash, I would have given him them. I hear that Frontinus Julius has for sale at a high price the leather ware (?) which he bought here for five denarii apiece. Greet Spectatus and... and Firmus. I have received letters from Gleuco. Farewell. (Back) Vindolanda."
>
> Tablet 88/946, from Bowman, Thomas and Adams, 1990, 44-45

Although it is clear that Octavius is concerned about receiving his hides (coria) from Catterick, and that these should have been sent already over the road system, it is not clear as to how these hides would have been transported over the roads. However, as he is unwilling to risk hurting the animals over the poor roads, it is likely that draught

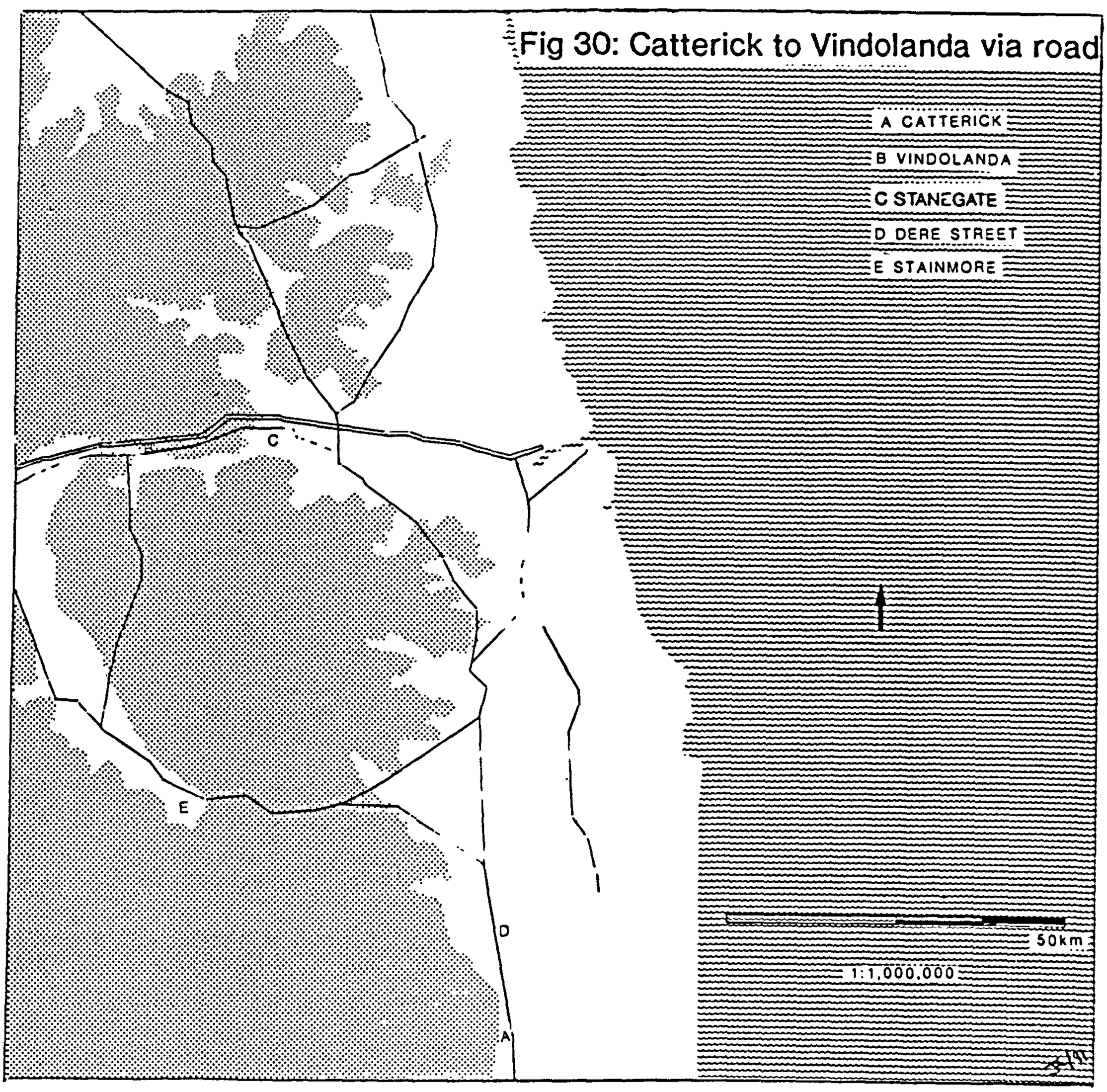


Fig 30: Catterick to Vindolanda via road
A CATTERICK
B VINDOLANDA
C STANEGATE
D DERE STREET
E STAINMORE
C
E
D
A
50km
1:1,000,000

animals pulling wagons, rather than pack animals would have been used.[1] The use of wagon transport is also suggested by Octavius' special request for a wagon which was to be sent to him.

Catterick, a Roman fort built under Agricola and occupied until ca 120 (Burnham and Wacher, 1990, 111) is situated on Dere Street just south of modern Scotch Corner, about 112km south of Vindolanda (see figure 29, 30),[2] and it is apparent through other correspondence that the two forts had close contacts (R E Birley, pers comm). Octavius' letter attests to goods transported along Dere Street overland to Vindolanda: either along Dere Street to Corbridge, and along the Stanegate to Vindolanda (discussed below, 6.2.1), or along Dere Street to the Stainmore, north to Carvoran, and east along the Stanegate to Vindolanda (see figure 30). Given the position of Corbridge as a 'hub' (discussed above, 2.2.2 and below, 6.2.1) at the junction of Dere Street and the Stanegate, it is likely that transportation followed the eastern route along Dere Street (Bowman, Thomas, and Adams, 1990, 43).

---

[1] Pack animals would have been less affected by poor roads. Indeed, before the advent of turnpikes in England, it was common to use pack animals instead of ox-carts when road conditions were particularly unfavourable (Pratt, 1912).

[2] This fort has been identified with Cataractonium of Ptolemy, the Antonine Itinerary, and the Ravenna Cosmography (Rivet and Smith, 1979; Burnham and Wacher, 1990, 111).

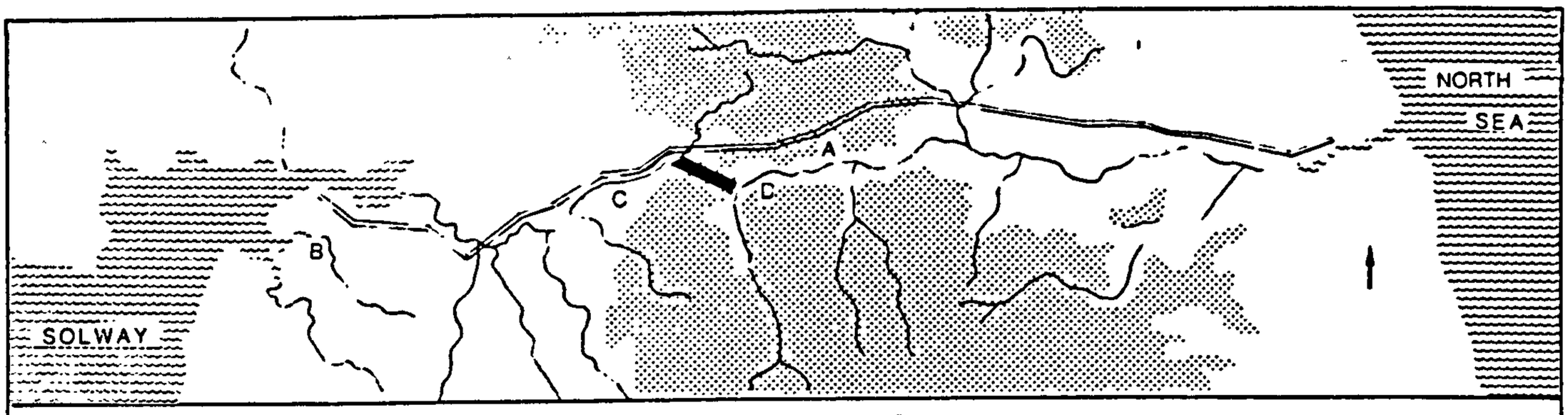


Fig 31: Supply to Vindolanda from Kirkbride by river

A VINDOLANDA

B KIRKBRIDE

C IRTHING

D SOUTH TYNE

E PROPOSED LOCATION OF CANAL CONNECTING IRTHING TO SOUTH TYNE

0 10km

1:1,000,000

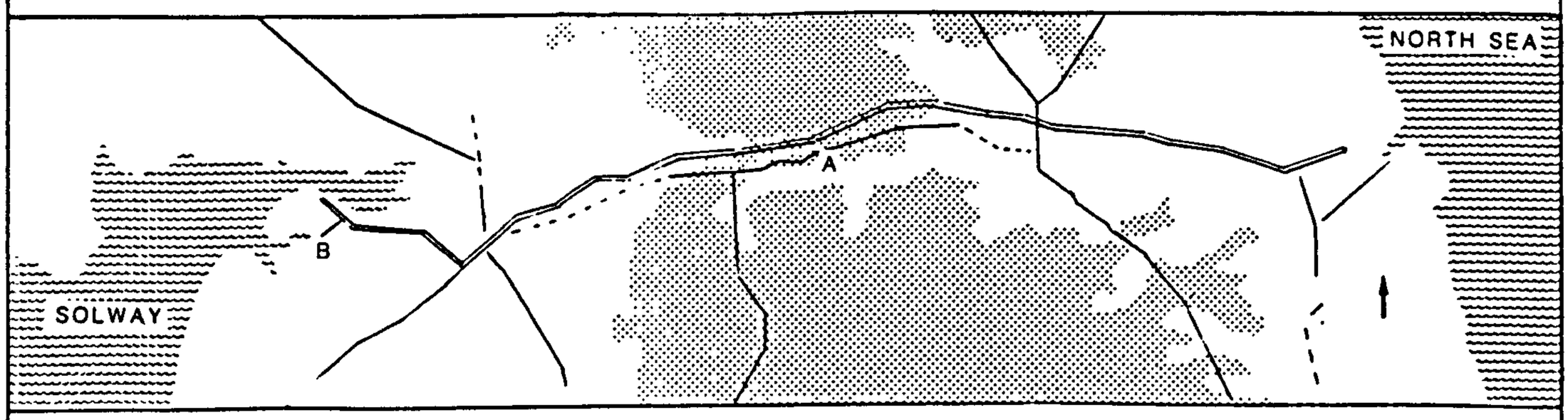


Fig 32: Supply to Vindolanda from Kirkbride by road

A VINDOLANDA

B KIRKBRIDE

0 10km

1:1,000,000

JS/91

Supply from the West. In addition, a writing tablet (Doc.4; Inv. 33,47,62; Layer 8), in part an account of foodstuffs distributed to soldiers over a period of several days at the end of June of an unspecified year (Bowman and Thomas, 1983, 85), mentions in its last lines 'domine brigae...[runt]'. It is possible that the Lords of Briga were responsible for the supply of these foodstuffs to Vindolanda (pers comm R E Birley; see figure 31, 32). Briga again is mentioned in another text (Inv. 85/42), suggesting strongly that it is a place name. Although the location of Briga is uncertain, Kirkbride on the west coast is a prime candidate. The correspondence suggests that it was no more than a couple of days journey away from Vindolanda (pers comm R E Birley).

Distribution from Vindolanda. Tablet T950, ca 90-100, suggests material was sent from Vindolanda to both Catterick and Vinovia (Binchester) lying ca 72km south of Vindolanda via Dere Street (pers comm R E Birley). As with Catterick, the route most likely would have been along the Stanegate to Corbridge, and south down Dere Street to Binchester (figure 34).

4.4.2 Conclusion

Negative epigraphic evidence from the Vindolanda writing tablets argues against Piercebridge formula supply to or from Vindolanda. Indeed, Piercebridge formula supply between Vindolanda, Catterick, and Binchester would have required construction and maintenance of components along the South Tyne, Tyne, Wear, and Tees, while supply from Kirkbride would have required the same along the Eden, Irthing, and South Tyne

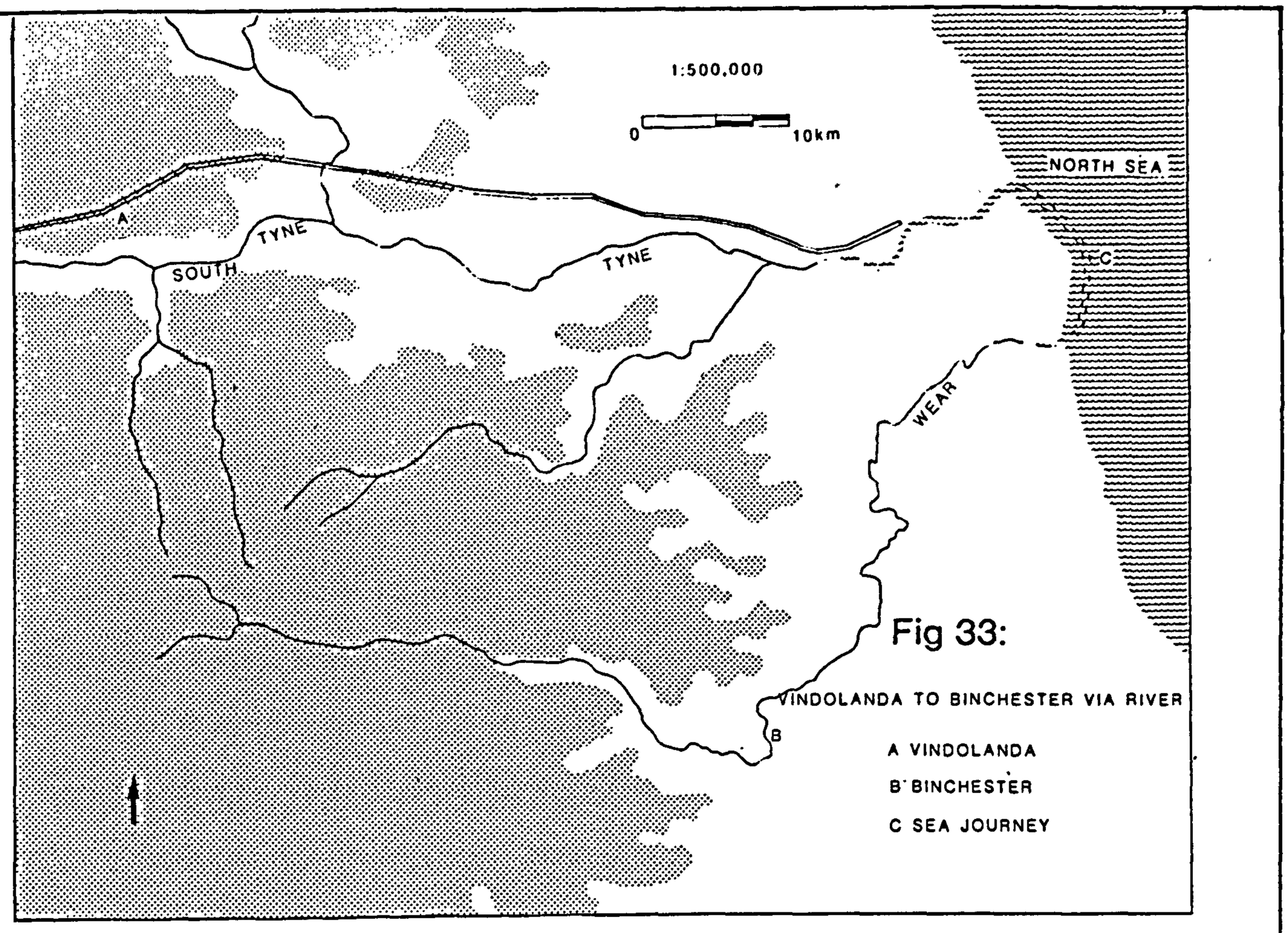


Fig 33: VINDOLANDA TO BINCHESTER VIA RIVER

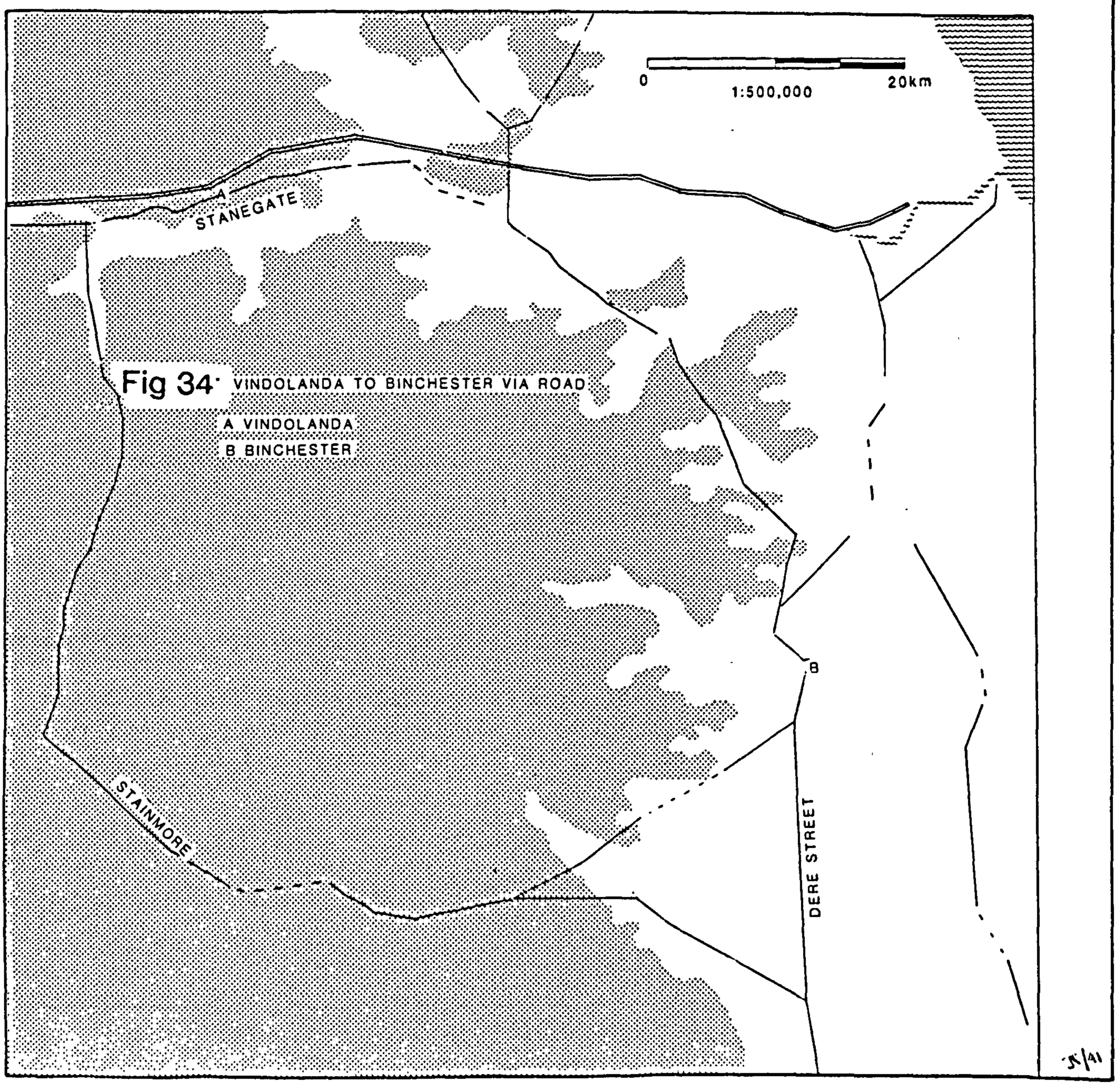


Fig 34: VINDOLANDA TO BINCHESTER VIA ROAD

above Vindolanda. However, no mention of such supply is found in the corpus of the Vindolanda writing tablets. Conversely, this contrasts sharply with the wide range of descriptions of long distance overland transport to and from Vindolanda. The absence of any reference to river-borne supply in the Vindolanda writing tablets conforms with the equally scant archaeological evidence for the Piercebridge formula along the river systems to Vindolanda, and, it seems, the total lack of mention of the Piercebridge formula throughout ancient literature (discussed in Appendix G).

CHAPTER FIVE

EVIDENCE: AREA 3

After passing northwards through the Wall at Portgate into Area 3, Dere Street enters into an area much different than Areas 1 and 2. First, the geography in Area 3 is dominated by the large hills of the Cheviots and east Uplands district. Dere Street, the Devil's Causeway, and the Bremenium-Thrunton cross road, as well as the many rivers in this area must pass through these hills. The largest rivers - Blyth, Wansbeck, Coquet, and Aln - descend rapidly west to east from great heights down to the sea, while the Rede drops from the highlands to meet the North Tyne at Bellingham. If developed with Piercebridge formula components, the steep gradients and significant drop in elevation of these rivers would have required many static barriers.

Second, this area was situated beyond Hadrian's Wall and outside the province and Empire for most of the Roman period. Roman forts, roads, signal stations, and marching camps attest to a Roman period military presence in this area over a long period. However, unlike the natives in Areas 1 and 2 living in Romano-British settlements adjacent to forts or further afield who were subservient to the Roman provincial administration, the relationship between soldiers posted in the various outpost forts and the natives in this area is very uncertain (discussed below, 6.2.3).

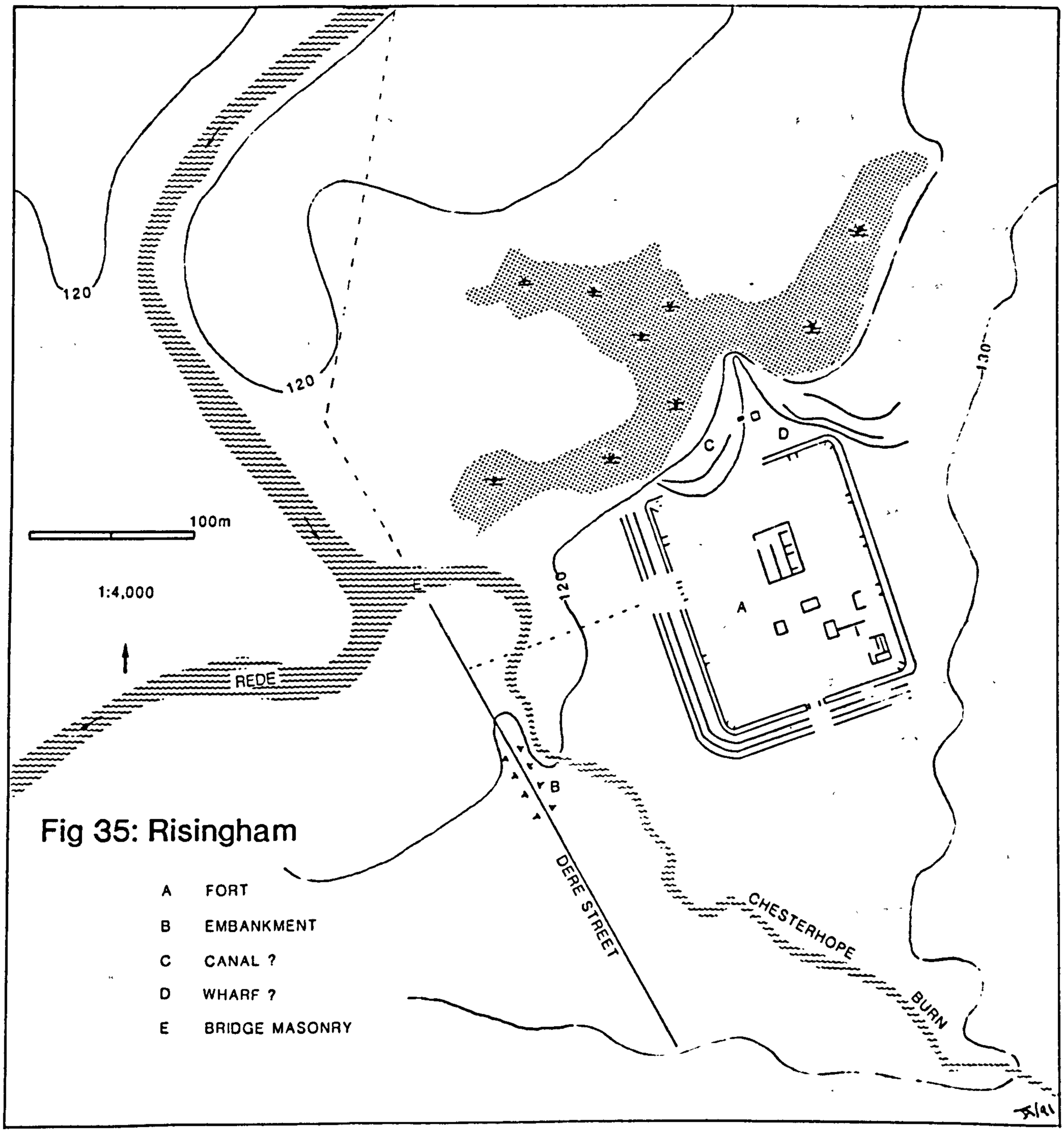


Fig 35: Risingham

A FORT

B EMBANKMENT

C CANAL ?

D WHARF ?

E BRIDGE MASONRY

An examination will be made of three sites and their environs for evidence of Piercebridge formula components in Area 3. Risingham on the River Rede and Brinkburn on the River Coquet are sites where more Piercebridge formula components have been described than at any other sites on their respective rivers. In addition, Low Learchild fort on the River Aln will be examined.

5.1 RISINGHAM

Risingham fort lies 28.5km north of Corbridge along Dere Street, and is situated on a flat till sheet overlooking the marshy valley of the Rede and Chesterhope Burn (see figure 35). Covering three periods - Antonine, Severan, and Constantinian - the fort was designed with a south-facing main gate and a later 4th century west-facing gate. A civilian settlement may have existed adjacent to the fort (Salway, 1965, 110-111; Clack, 1982, 398).

It is argued (Selkirk, 1983, 155-156) that the fort at Risingham was supplied by river barge via the rivers Rede, North Tyne, and Tyne. The Rede would have served as a transportation/communication link to forts along and south of Hadrian's Wall, such as the supply base at Corbridge 42.8km downriver. As the Rede's waters eventually flow into the Tyne, Risingham could have been provisioned ultimately from sea-going ships putting into South Shields. Risingham lies a full 52km above the Tyne's tidal limit, and 126m above sea level, so that 41 Piercebridge formula dams would have been required for the navigation of barges to Risingham

Right *Risingham Roman fort (Habitancum), Northumberland. On the north wall of the fort at* **C** *a peculiar construction still exists. This is described in various books as a stone groyne, built by the Romans to prevent the fort wall being washed away. The author, however, thinks that the channel* **A** *marked on maps as an old course of the River Rede is, in fact, a Roman barge harbour, and that the stone construction* **C** *was a ramp from the fort's north gate down to the wharf. Floods have washed away part of the fort wall at* **B** *but, if this happened in Roman times, a groyne at* **C** *would have been of little use. If channel* **A** *was an old river loop which caused trouble to the Romans, it would have been only one day's work for the garrison to fill in the loop and re-route the river further to the west. Expensive stonework would not have been necessary.*

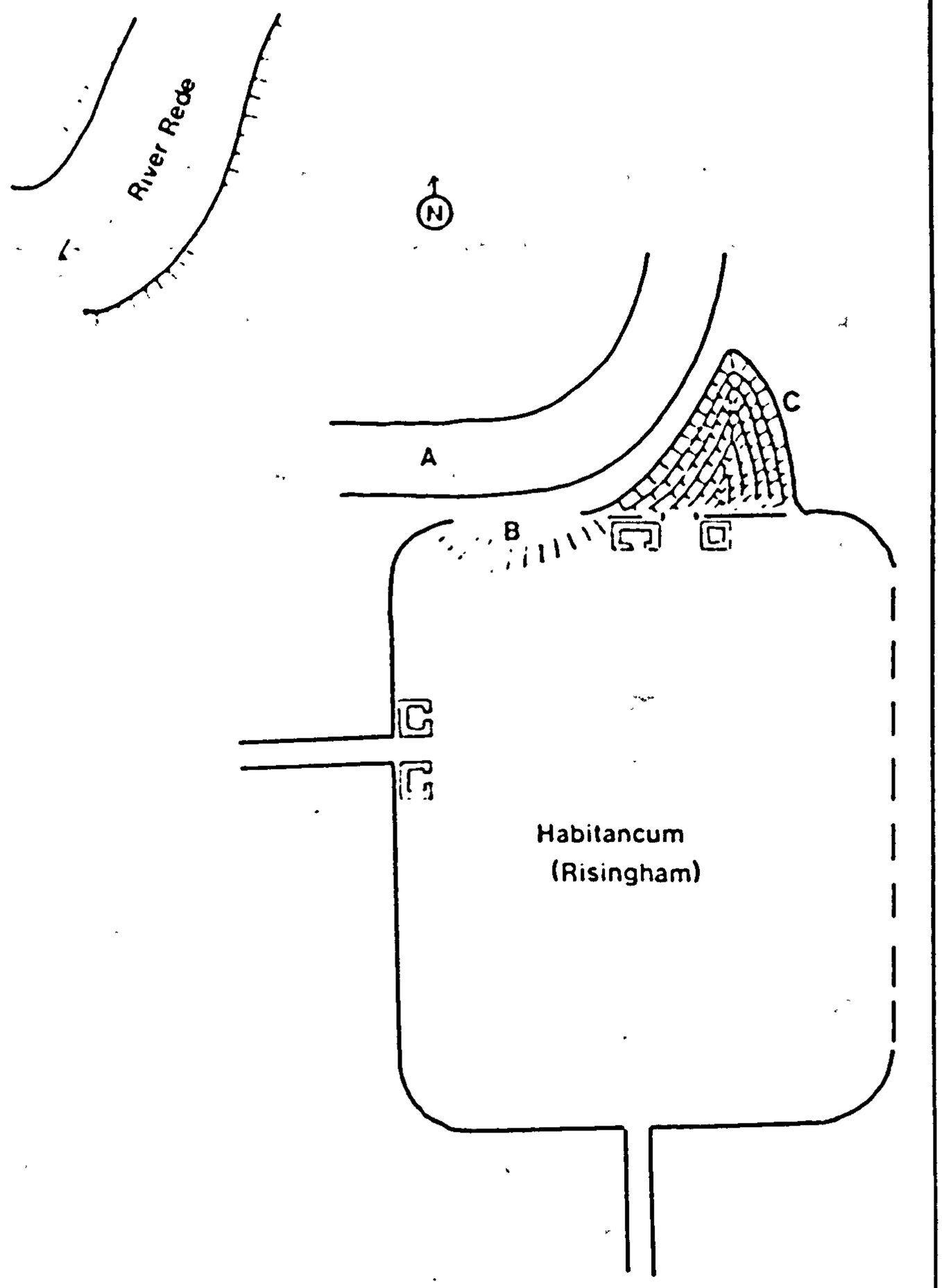


Fig 36: Selkirk's Risingham

Note the masonry drawn in 'barge wharf'.

From Selkirk, 1983, 155.

Fig 37: RIB 1225, from Collingwood and Wright, 1965.

1225

[D]eo | Mogonti ✶ Cad(. . .) ✶ | et N(umini) d(omini) n(ostri) Aug(usti) | M(arcus) G(auius?) Secundinus | [b(ene)]f(iciarius) co(n)s(ularis) Habita|nci prima stat-(ione) | pro se et suis posu[it]

"To the god Mogons Cad(. . .) and to the Deity of our Lord Augustus, Marcus Gavius Secundinus, *beneficiarius* of the governor, on his first tour of duty at Habitancum, set this up for himself and his own.'

1. *Cad*, probably a 'territorial epithet' which 'may well be a German *pagus*-name' Richmond loc. cit., p. 86. 5. *prima statione*, 'first tour of duty' Birley loc. cit. *Habitancum*, Risingham.

For Mogons see *RIB* 971 (Netherby), for Mogtis 921 (Old Penrith), for Mountis 922 (do.), for Mountes 1269 (High Rochester), for Mounus Cad. 1226 (Risingham).

For Mogontia see *CIL* xiii 4314 (*ILS* 4706) near Metz; for Mogounos *CIL* xiii 5315 (*ILS* 4649) Horburg, Alsace.

1. DEO Camd., Richm., R. P. W. 2. MOGONIT Camd. *Cott. Jul.*, R. P. W.; MOGONTI Camd. 1607, Hueb. 7. POSVIT Camd. *Cott. Jul.*, 1607; POS Hueb.; POSV[IT] R. G. C., R. P. W.; VS[LM] Richm.

For *beneficiarius* see Index 6.

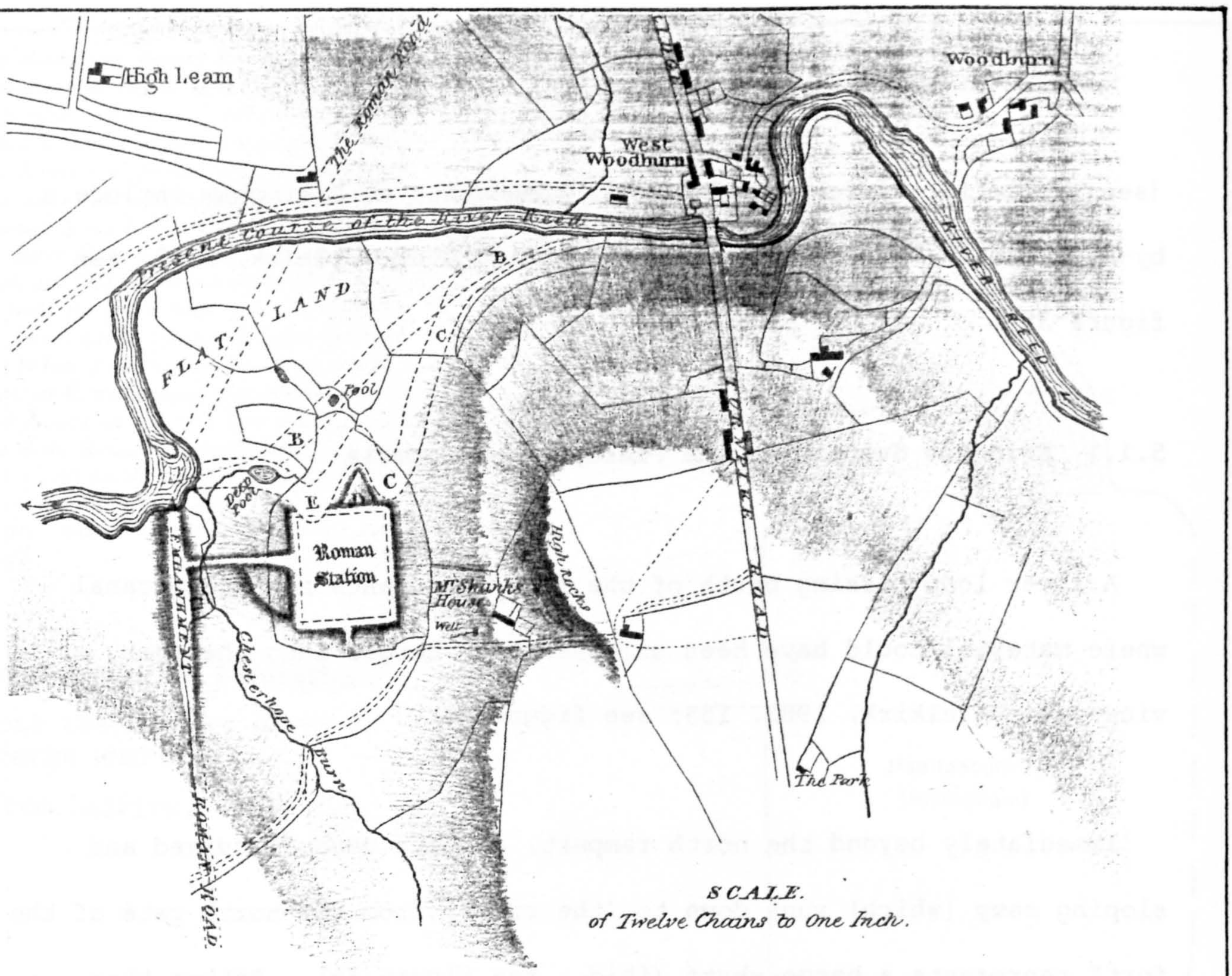
(see Table 1). Piercebridge formula components at Risingham include a by-pass canal, barge-wharf, dam and loading dock (Selkirk, 1983; see figure 35).

5.1.1 Evidence Supporting the Piercebridge formula

A river loop passing north of the fort represents a by-pass canal where material could have been unloaded from barges into the fort, or vice-versa (Selkirk, 1983, 155; see figure 49).

Immediately beyond the north rampart, a "very unusual curved and sloping ramp [which] runs down to [the river] from the north gate of the fort" represents a barge wharf (ibid.; see figure 36). Rather than Bell's explanation that this was a weir or 'groyne' to "defend the fort from an outbreak of the river" (Swinburne, et al, 1844, 10; see figure 38, 39), this barge wharf would have received supplies taken by porters or mules from the barges through "the front gate of the fort" (Selkirk, 1983, 155). Further, Bell's account (Swinburne et al, 1844, 10) attests to the existence of stone in this structure:

> "The wear, extend[ed] almost 90 yards [82.4m] to the north of it ... and, were it opened out, I have not the least doubt but it would be productive of vast quantities of stone; and, more than likely, many inscriptions, as two of the monumental stones ... were found near the south end of the wear, where they had been used as walling stones. The station has been excavated in its eastern and southern sides for the purpose, I believe, of covering the earth over the stones which compose the wear."



A. *Foundation of a Bridge seen here.*

B B. *Supposed Course of the River Reed when the Bridge and Station were built.*

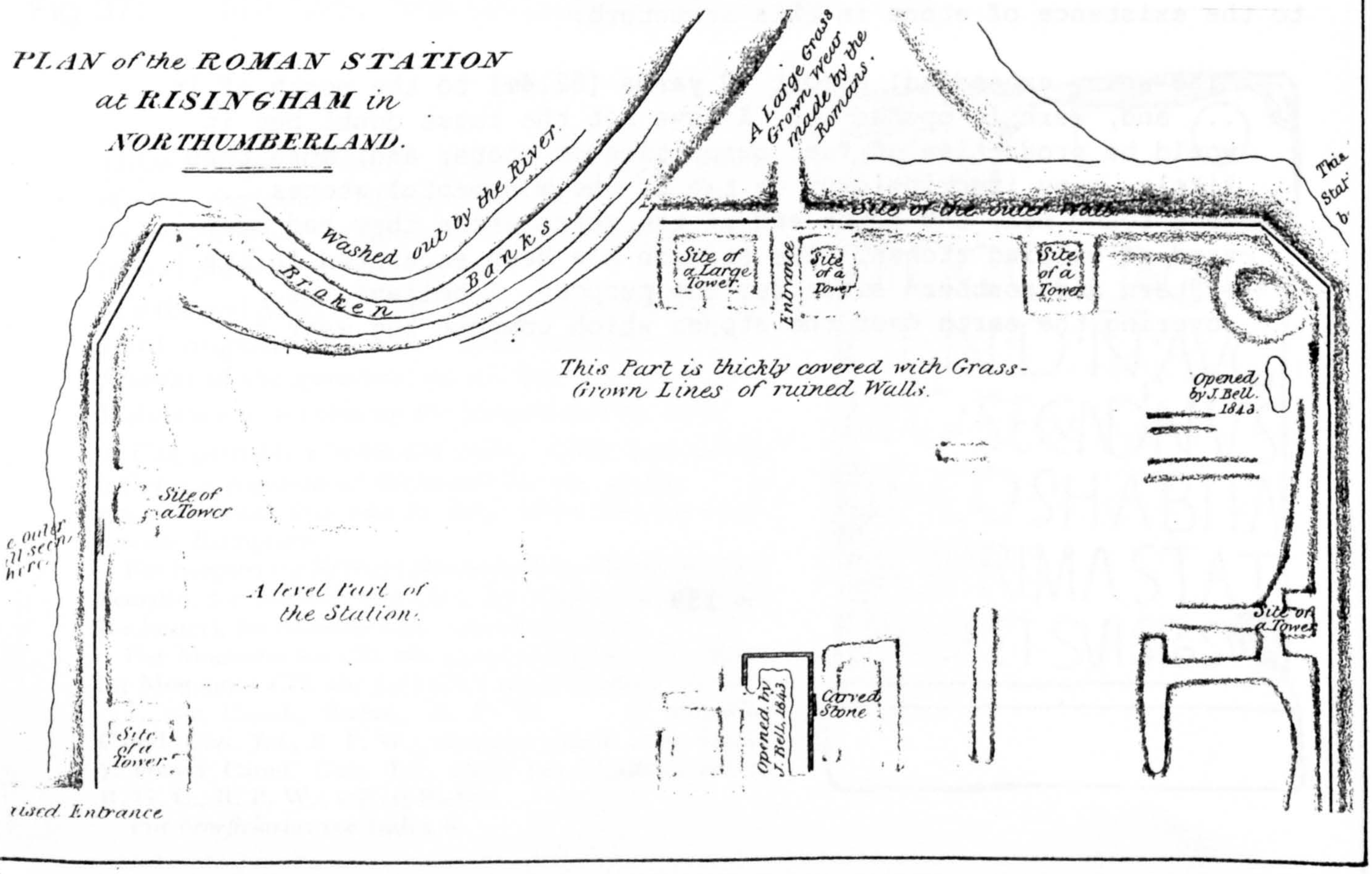
C C. *An outbreak of the River which threatened the destruction of the Station*

D *Large Wear made by the Romans to protect the Station.*

E *A second Outbreak of the River round the North end of the Wear and breaking into the Station.*

Fig 38: Plan of Risingham fort by Bell in Swinburne et al, 1844.

Fig 39: Exploded plan of north aspect of Risingham fort showing 'wear', by Bell in Swinburne et al, 1844.



Large dressed stones with dove-tail cramp holes at a point where the Chesterhope burn meets the Rede represent a Roman dam (see plate 36): this dam would have allowed navigation further up the Rede to forts at Blakehope and High Rochester (Selkirk, 1983, 156).

Finally, a loading dock would have existed at the site of the dam (ibid.).

5.1.2 Evidence Refuting the Piercebridge formula

By-pass Canal

The by-pass canal seems rather to be the feature described in 1844 (Bell in Swinburne, et al, 1844) as a former course of the River Rede. After examining Tithe Plans, Bell identified three former courses of the river: a first outbreak (CC, figure 38) occurred after construction of the fort and threatened its destruction, forcing construction of the 'weare' or 'groyne'; a second outbreak (E, figure 38, and the 'by-pass canal') undermined the north rampart of the fort; and a third outbreak (BB, figure 38) ran north of this channel, and south of the modern river channel.

Geo-morphological analysis. In order to determine the nature of these channels, as well as the local and regional Roman period environment, a geo-morphological analysis of the Rede's valley floor morphology and sediments was undertaken in May, 1990 (for a detailed study, see

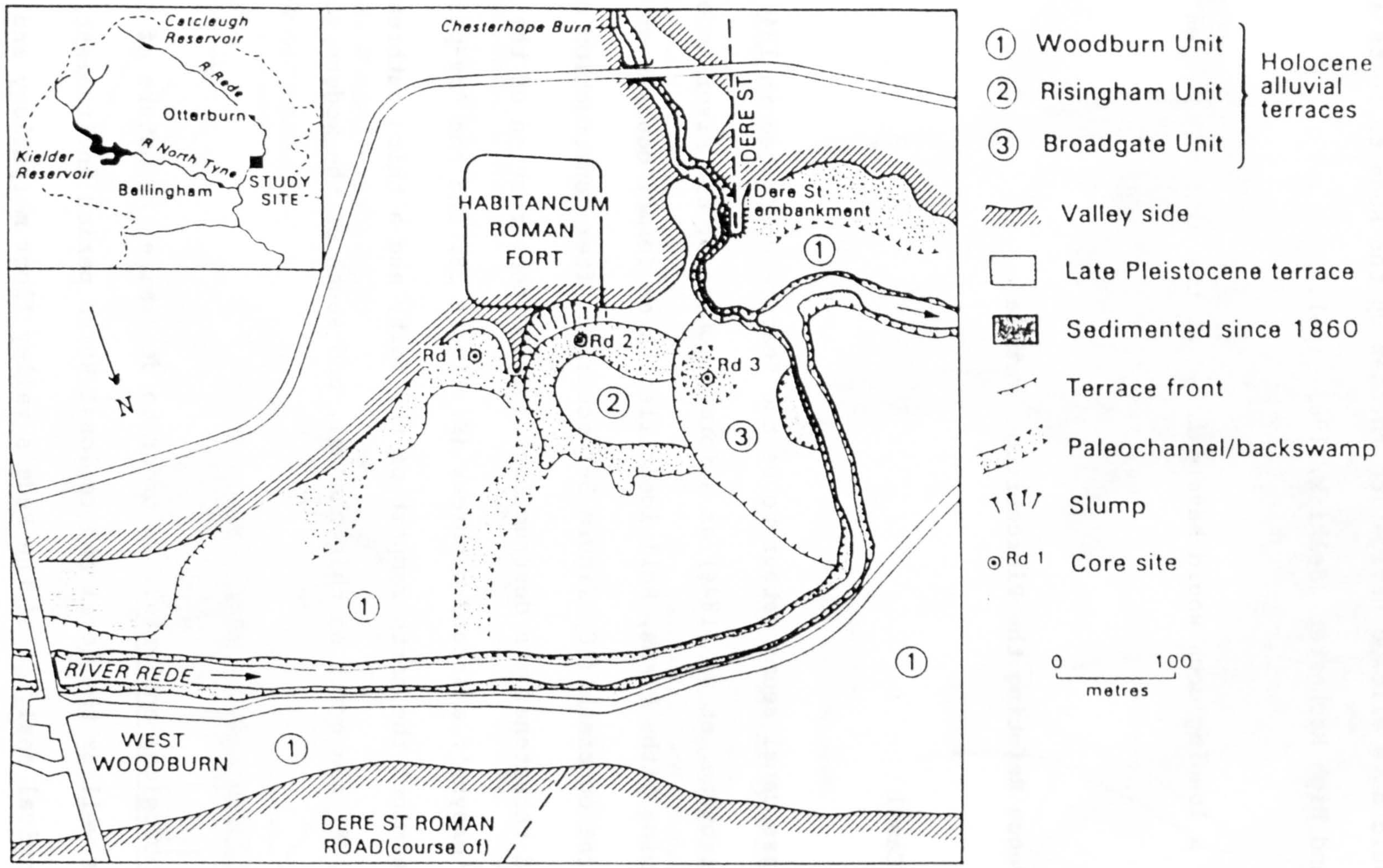


Fig 40: Valley floor morphology at Habitancum, showing Holocene alluvial fills, palaeochannels and backswamps.

Passmore, Macklin, Heap, and Anderson, 1990). Two sediment cores were subjected to sedimentological, geo-chemical and pollen analyses, while radio-carbon dating of wood fragments from one of these cores provided a chronological framework for the study. In addition, through detailed morphological mapping and surveyed cross-sections of the valley floor, height relationships and relative ages of Holocene alluvial fills have been established.

Sitting upon a soliflucted till sheet, Risingham fort overlooks an alluvial basin extending 1.5km east-west by .5km north-south, and comprising at least two separate alluvial fills with associated palaeo-channels infilled with holocene sediments.

The 'Woodburn unit' corresponds to Bell's course 'CC', running immediately north-east of the fort, and east of Bell's so-called 'groyne' (see figure 39). It has a surface elevation 4.5m above the modern river bed, and includes a water-logged and meandering palaeo-channel cut into the lower valley side below the fort (see figure 40). 'Reed 1' sediment core extracted from this channel included a total of .25m of fine sandy gravels and sands overlain by 1.25m of peaty clays and silts. Wood fragments from depths of 1.05m and 1.2m returned radio-carbon dates of 1350 +/- 70 BP (Beta-37811), or AD 600 +/-70, and 1300 +/- 70 BP (Beta-37810), or AD 650 +/-70, respectively. These dates prove Bell correct: the Woodburn unit and Bell's course ' ' (1844) represents the oldest (and most extensive) of the Holocene terraces in the Rede valley below Risingham. These dates also point to an abandonment and infilling

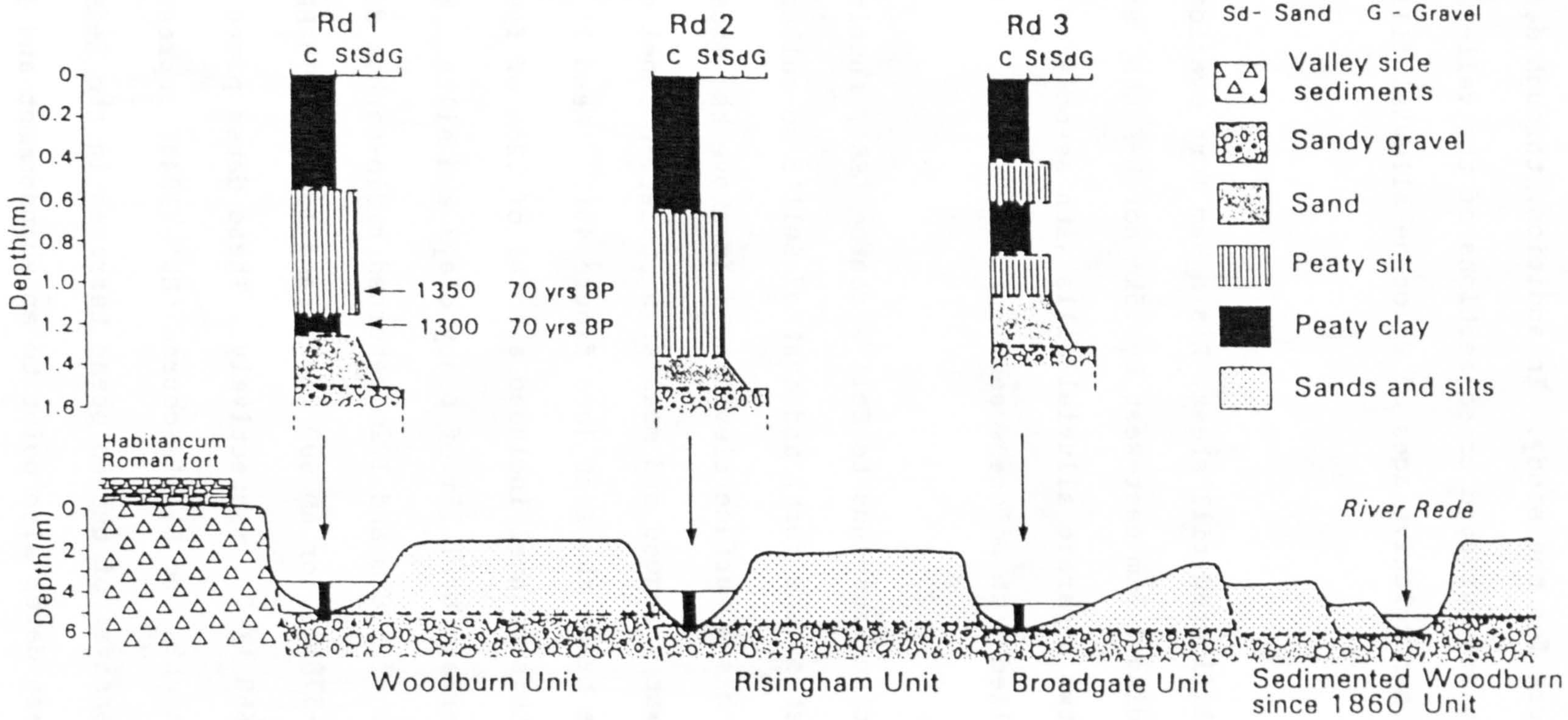


Fig 41: Schematic cross-section of the valley floor at Habitancum, showing height relationships and sedimentary properties of Holocene alluvial fills, palaeochannels and backswamps.

of the Woodburn unit by AD 600-650, ca 200 years after the Roman period. Although the onset of the alluviation phase is as yet undated, it is most likely that the valley floor to the north of the fort during the Roman period was dominated by the undissected and aggrading Woodburn unit.

At first glance, this seems to support Bell's theory that the 'groyne' was built during the Roman period to prevent the Rede from undermining the north-east part of the fort. However, the river channel in the Roman period was markedly more sinuous than at present. Given the potential for high rates of lateral migration in such channels, the Woodburn unit palaeo-channel was probably a further distance from the fort in the Roman period than when it was eventually cut-off by the later Risingham unit (below). Indeed, limited aggradation of the Woodburn unit likely continued after the Roman period, thus burying the contemporary floodplain. Therefore, although the Woodburn unit may have been moving towards the fort in the Roman period, it was probably still beyond the point at which it would have posed a threat to the north-eastern defences.

The Woodburn unit was truncated by the younger alluvially-filled Risingham unit lying immediately north-west of the fort (see figure 40), at which point the Woodburn unit began infilling with vegetation.[1] Approximately .5m lower than the Woodburn unit, the Risingham unit also

---

[1] The radio-carbon dated wood is representative of such vegetation growing in the bottom of an abandoned, infilling channel.

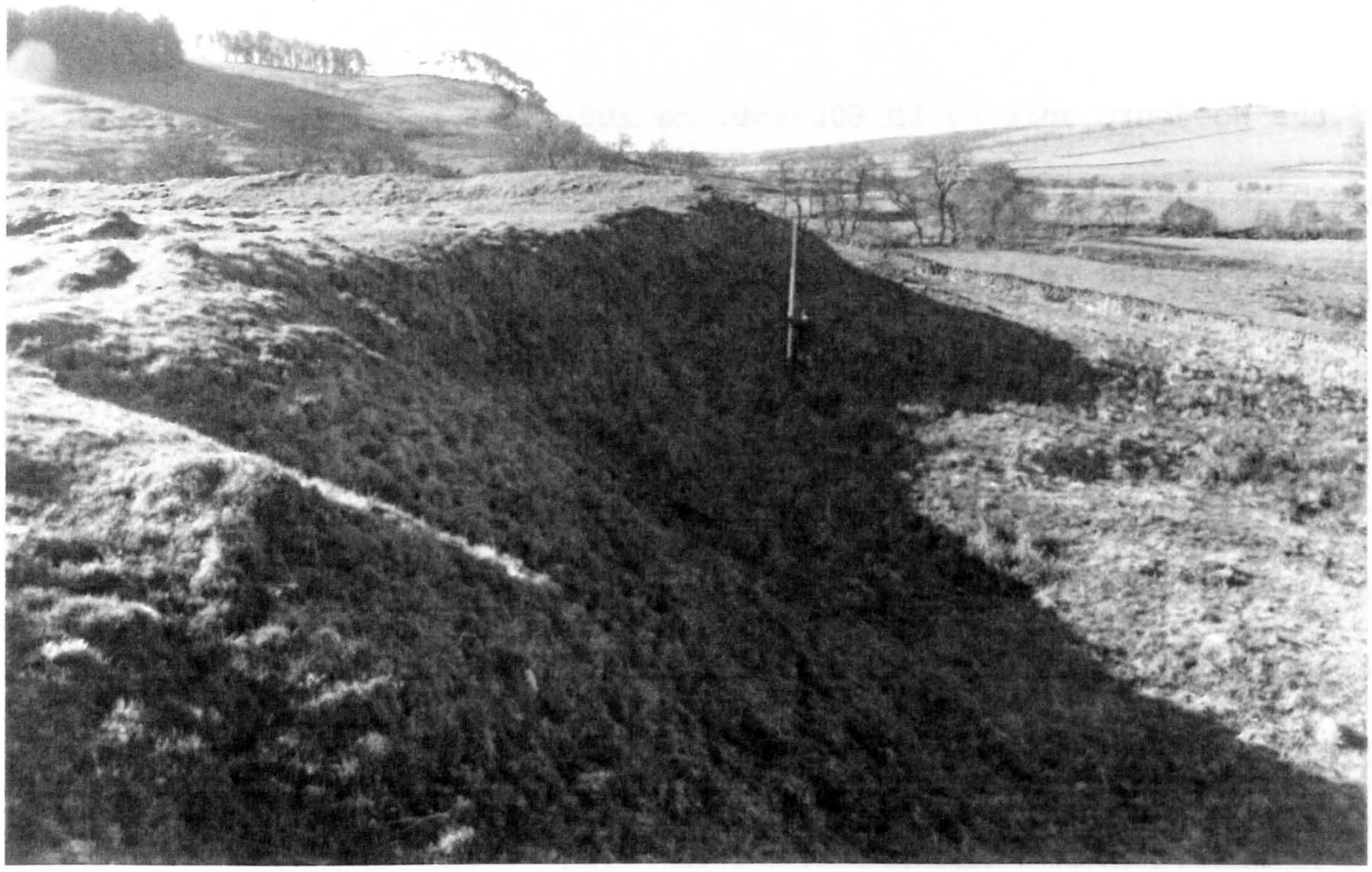


Plate: **30** West aspect of north rampart at Risingham fort; east facing west; Note indentation of Bell's river course 'E' (see figure above), 11m into north rampart.

Plate: **31** Bell's so-called 'wear' or 'groyne' extending north beyond the north rampart of Risingham fort; south facing north (approx.).

includes a sinuous and water-logged palaeo-channel, or Selkirk's 'by-pass canal' west of the 'groyne'. Analysis of sediment core Reed 2 revealed that this channel had a comparable depth and sedimentary sequence to that of Reed 1. Aggradation of this channel resulted from a sinuous and laterally mobile river channel, and continued south-easterly migration trimmed the lower valley side. This migration eventually resulted in the slumping and destruction of the northern rampart, and the development of the elongated spur of land north of the fort, or the 'groyne'. Because the Woodburn Unit was truncated by the Risingham unit, the radio-carbon date of AD 600-650 represents the terminus post quem of the Risingham unit, so that this channel, or 'by-pass canal', did not begin forming until two hundred years after the Roman period.

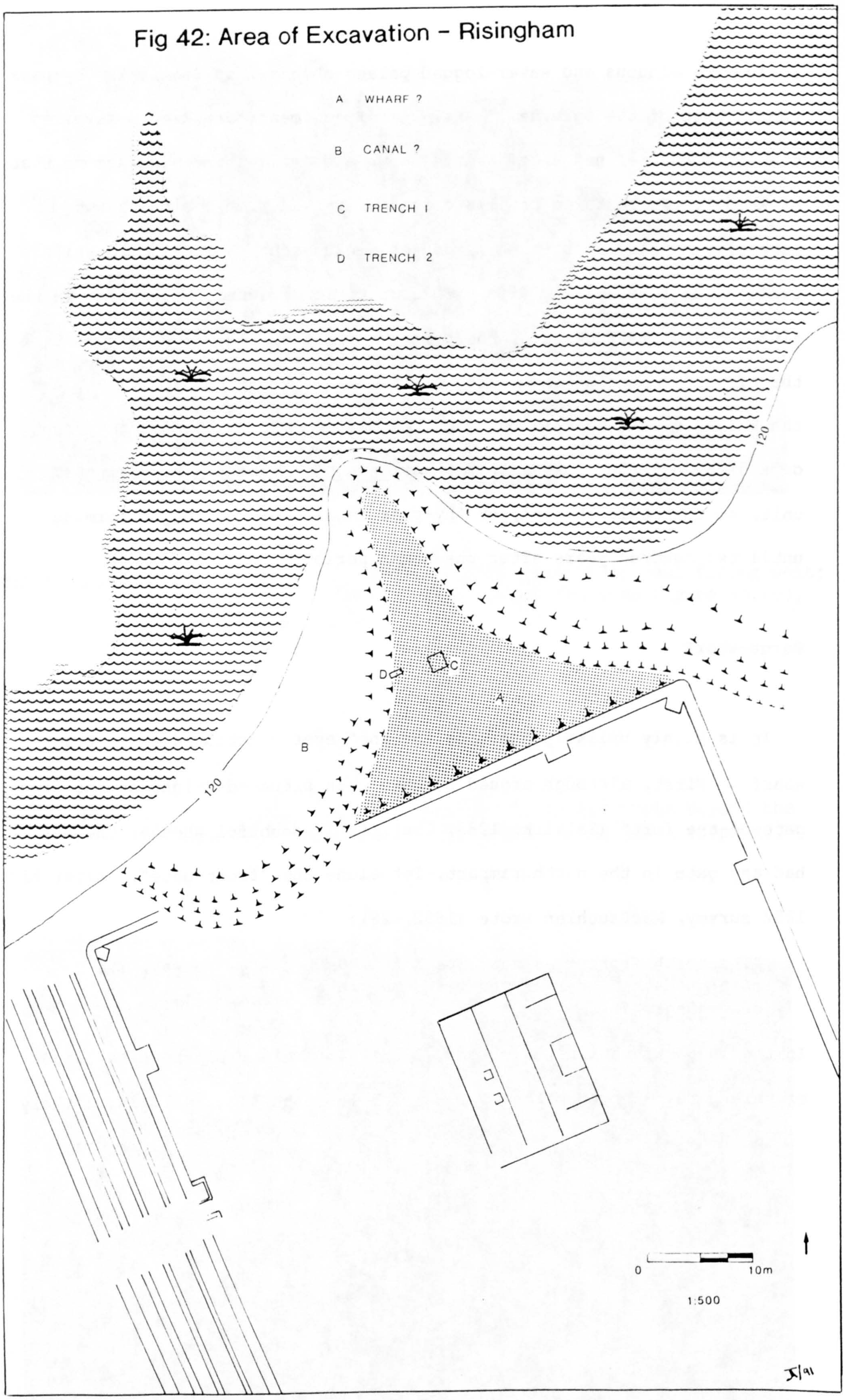
Barge-wharf

It is highly unlikely that the 'groyne' ever functioned as a 'barge wharf'. First, although argued to have been situated "right at the front gate of the fort" (Selkirk, 1983, 156), it is doubtful whether the fort had any gate in the north rampart, let alone the "front gate". After his 1852 survey, MacLauchlan wrote (1852, 28):

> "The north front does not appear to have had any gateway, its resting on the bank of the river may have rendered it unnecessary;"

In the 1935 excavations, Richmond (1936) also was unable to find traces of this gate. Construction of a wharf below a gateless wall is unlikely.

Fig 42: Area of Excavation – Risingham



More importantly, the geo-morphological analysis has shown that the the left or west bank of the 'barge-wharf' is cut by the 'by-pass canal': the date for the latter must also date the formation of the left aspect of the barge-wharf to at least 200 years after the abandonment of the fort.

However, Bell's speculation that "vast quantities of stone" from a Roman structure exist below the topsoil of the 'groyne' has been influential up to the present. Indeed:

> "In front of the probable site of the north gate at Risingham a large 'wear'... was constructed which extended 82.3m from the fort wall, and was composed largely of re-used masonry, which included some inscribed material... It appears to have been a particularly massive quadrilateral structure which prevented the Rede cutting into its southern bank and threatening the safety of the fort defences. Its construction is undated but it is probably to be placed quite late in the history of the fort."
>
> Bidwell and Holbrook, 1989, 114

However, as for the inscribed stones, Bell states (Swinburne, et al, 1844) that the stones of the 'groyne' "more than likely were re-used masonry in a reconstruction of the north rampart": therefore, the stones may have been tumble from the fallen rampart, with no connection to the 'groyne'. Nevertheless, in response to Bell's speculation of "vast quantities of stone", an archaeological excavation was carried out over the 'groyne', or Selkirk's 'barge-wharf'.

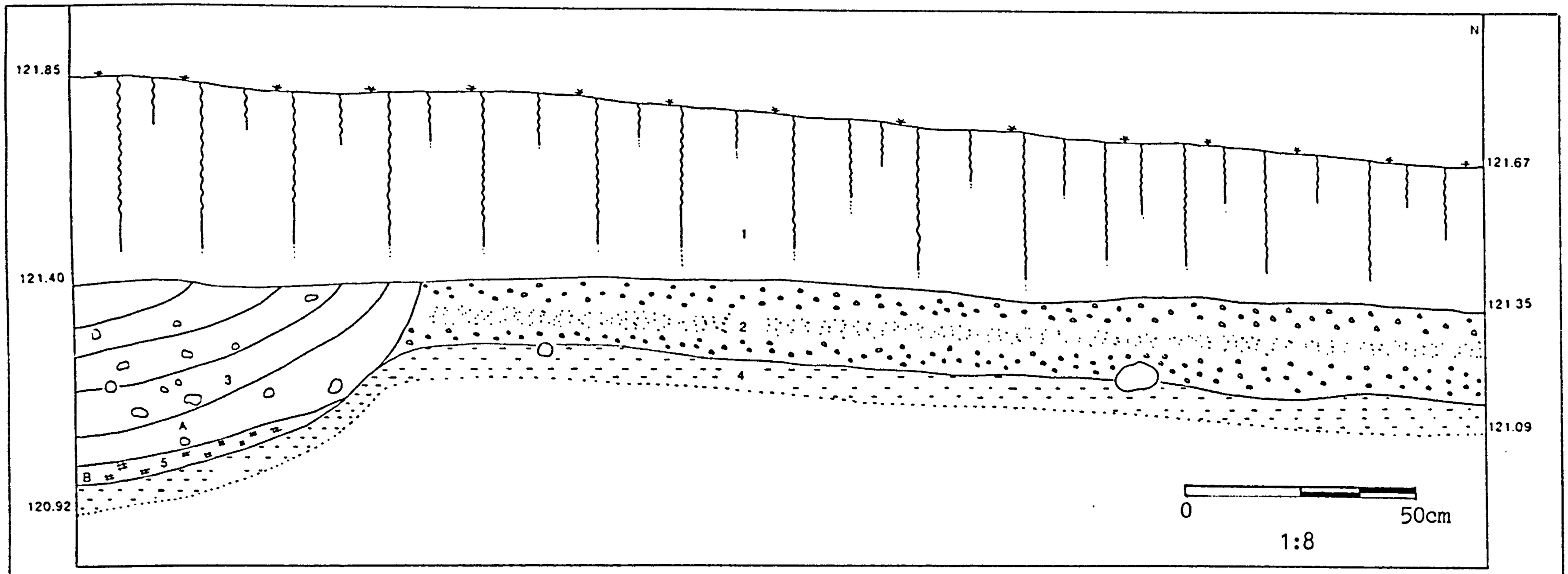


Fig 43: Section of Trench 1, Risingham

EAST FACING WEST

MAY 12, 1990

EM: 121.85m OD

TOPSOIL (1)

SUBSOIL (2): PEBBLE/SAND, SILT; ORANGE

PIT (?) (3): LOOSE, FRIABLE, BANDED

PLEISTOCENE SILTS (4) VERY HARD; YELLOW

CHARCOAL TRACES

LIMIT OF EXCAVATION

A SAMIAN WARE

B CHARCOAL SAMPLE

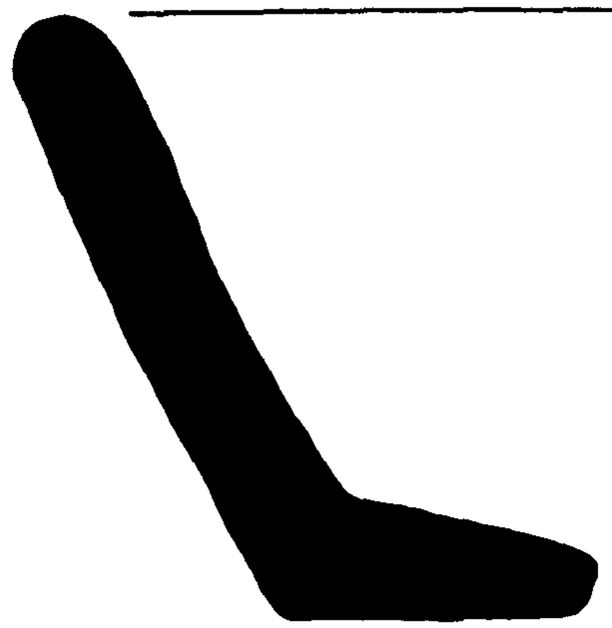
Excavation: May 12, 1990. Before laying out trenches, the 42m width (maximum) and 63m length of the 'groyne' was probed at roughly 3m intervals for sub-surface masonry. However, the probe penetrated 2m with no obstructions.[1] At the same time, the 1896 benchmark on the south-east side of the fort was carried down to the south-west peg of Trench 1, measuring 121.85m OD.

Trench 1 was laid out over 3x3m approximately in the middle of the 'groyne' (see figure 43). After stripping the turf, the topsoil (context 1) measured .45m deep, and consisted of very moist, rich, dark soil (see figure 43, plate 32). Beneath the topsoil, colluvial subsoil (context 2), again very moist, comprised an orange-coloured matrix of 60% pebble/sand 30% silt, as well as a smaller quantity of clay. Within this context was recovered Roman period pottery (discussed below).

A feature (context 3) was found cutting through the subsoil in the south-west aspect (see figure 43, plate 33) under apparently undisturbed topsoil, suggesting a sealed context. This feature consisted of pebbles/sand, as well as loose, sometimes friable, moist soil, deposited in bands curving .6m north of the south baulk, downwards and under the south baulk. Traces of charcoal, including one large sample, and Roman period pottery (discussed below) were recovered in the bottom of this context.

---

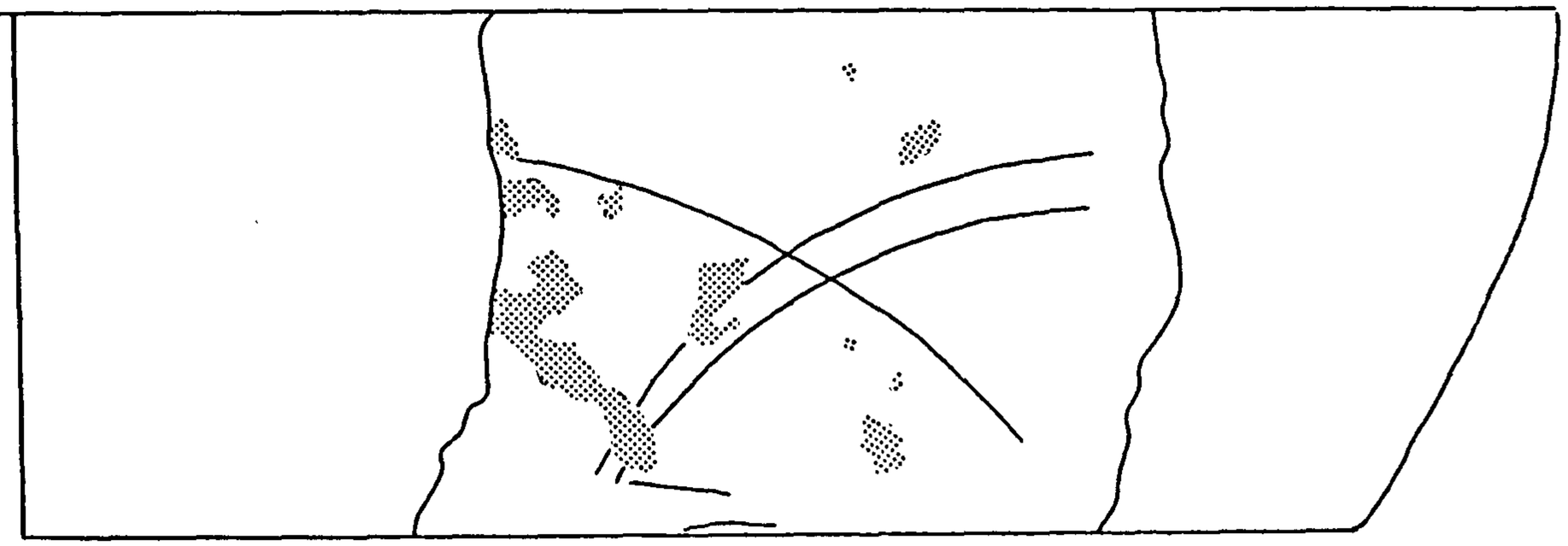
[1] The team consisted of four archaeological colleagues: Richard Carlton, Richard Willis, Alan Rushworth, and Dave Edwards; and a geo-morphologist: Dave Passmore.

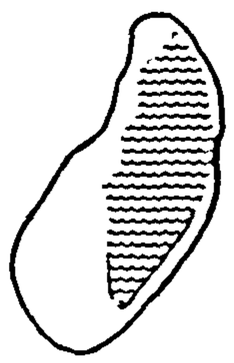


A. BB1 BASE/RIM GILLAM 329

C.190-340 AD

CONTEXT 2

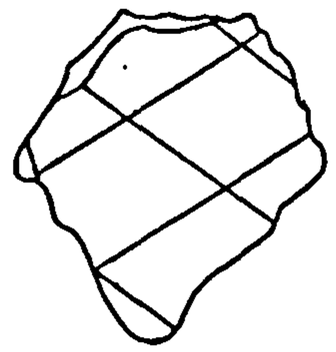




B. SAMIAN WALL SHERD

CENTRAL/EAST GAULISH 2ND TO MID-3RD C AD

CONTEXT 3



C. BB1 COOKING POT WALL SHERD

OBTUSE LATTICE

3RD TO 4TH C AD

CONTEXT 2

Fig 44: Pottery from Trench 1, Risingham

1:1

0 2cm

GLAZE

ORANGE RESIDUAL DEPOSIT

J/91

Although only ca 50 per cent of this feature was recovered, it seems fairly certain to have been a back-filled pit. Alternatively, the feature may represent a ditch lying beyond the north rampart of the fort: however, as no surface undulations were apparent on either side of Trench 1, a ditch is less likely than a pit feature.

Beneath the subsoil and penetrated by the proposed pit is a layer of very hard soliflucted till silts (context 4), yellow in colour, artefactually sterile, and deposited in the pleistocene (pers comm Mr Dave Passmore). Excavation through this context was terminated at a depth of 15cm, with the consistency of the layer remaining uniform throughout.

Roman period pottery from Trench 1 was found in contexts 2 and 3 (see figure 44). The subsoil context 2 produced two sherds of pottery: a BB2 base rim and a BB1 cooking pot body sherd, while context 3 produced a sherd of samian ware.

The sherd marked 'A' in figure 44 measures 4.8cm from base to rim, and has orange patches on its outer surface. These patches might be residual deposits, or perhaps the result of accidental burning in partially oxidizing conditions (Gillam, 1970, 14). The dark-grey fabric contrasts with the grey-black surface, and the outer surface is decorated with incised lines which run in intersecting arcs. The complete pot profile, grey-black colour, burnished finish, and striated lines identify this sherd as Type 329 BB1, dated to ca AD 190-340, and part of a cooking-pot

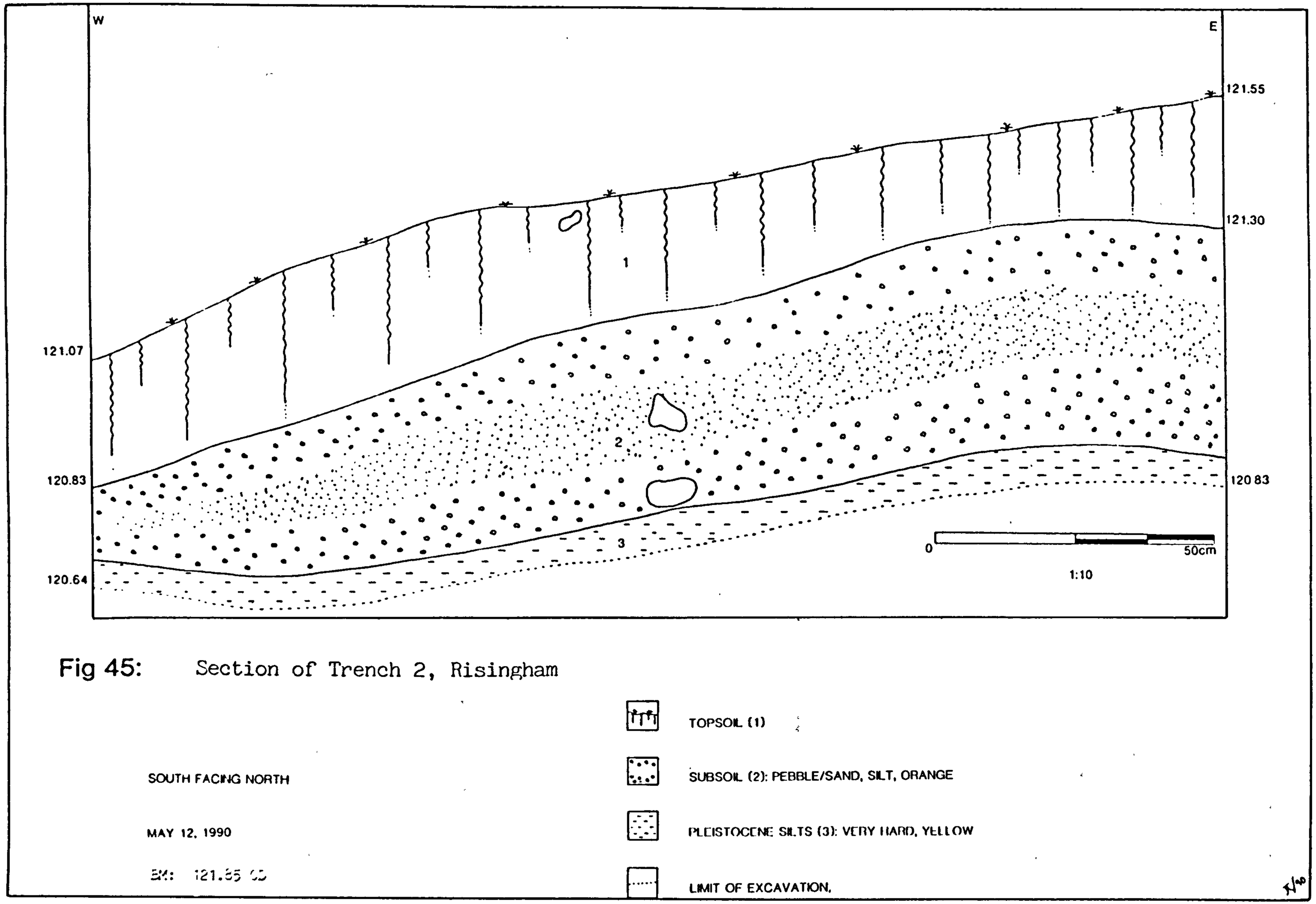


Fig 45: Section of Trench 2, Risingham

dish/platter with plain rim (Gillam, 1970, 33; pers comm Kevin Greene and John Dore).

The body sherd marked 'C' in figure 44 is less diagnostic. However, the black colour of fabric, its dark and polished surface, as well as the obtuse lines of decoration which intersect to form parallelograms on the outer surface, combine to suggest Type 146 BB1 (fumed) cooking pot dating to AD 280-350 (Gillam, 1970; pers comm Kevin Greene and John Dore).

The sherd marked 'B' in figure 44 and recovered from the proposed 'pit' feature in context 3 is samian ware. The presence of mica in the glaze indicates production either in Central or East Gaul, from the 2nd to mid-3rd centuries AD (pers comm Kevin Greene and John Dore).

The presence of BB1 sealed within the subsoil suggests that context 2 was an occupation layer from the 2nd to 4th centuries AD. These pieces may have been either rubbish strewn randomly outside the fort, or perhaps were part of a larger and unknown dump in the vicinity. Because context 3, the proposed pit, cuts into context 2, the BB1 date represents a terminus post quem for the digging of the pit. This is supported also by the date of the samian in context 3.

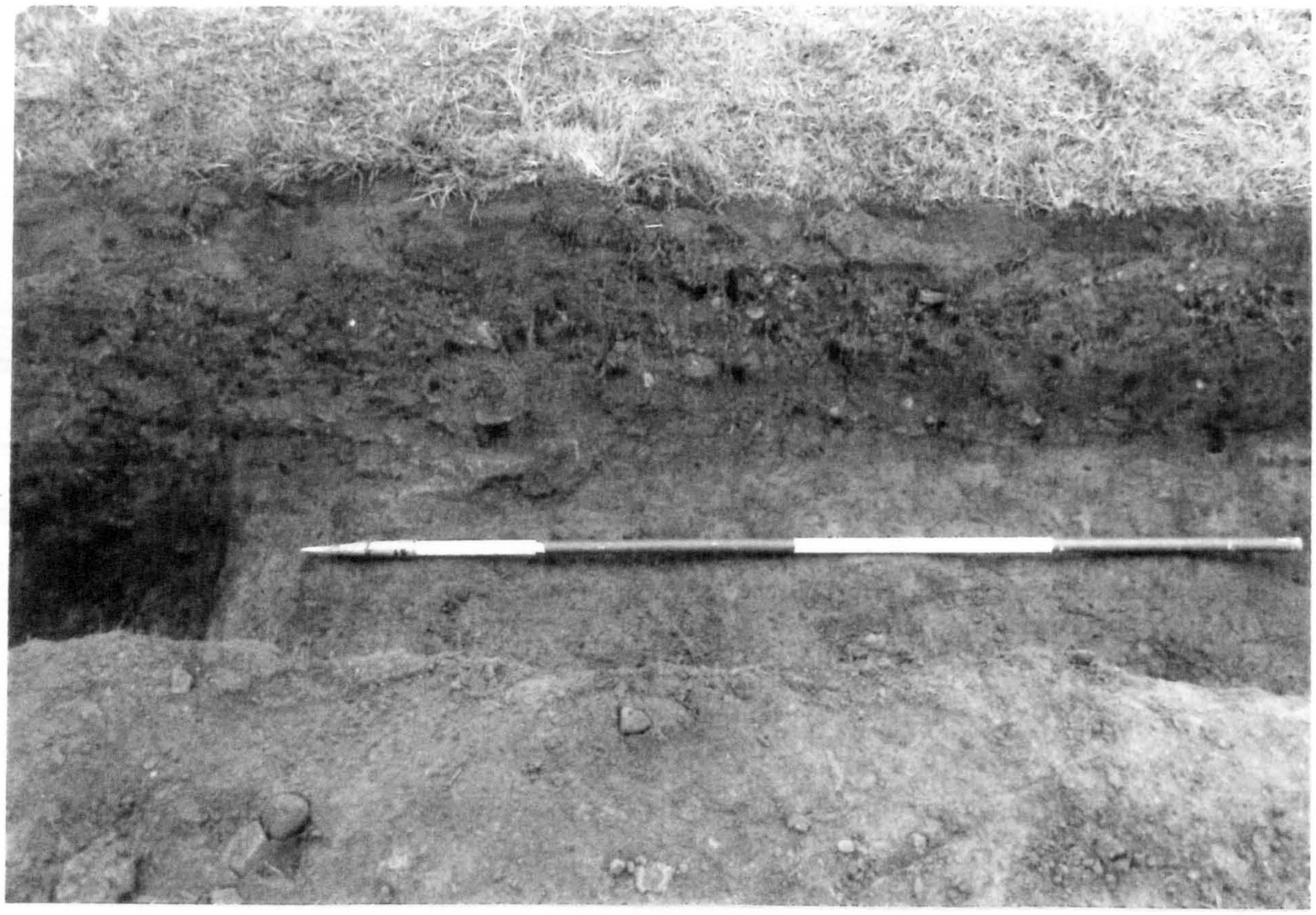


Plate: 32 Section of Trench 1, east facing west, on the 'groyne' at Risingham Roman fort. Note 'pit' feature in south aspect cutting into pleistocene silts.

Plate: 33 Feature in south aspect of west baulk of Trench 1, in 'groyne' at Risingham Roman fort, east facing west.

Trench 2 was excavated 3m directly west of Trench 1. According to the Piercebridge formula, barges would have been towed along the by-pass canal and unloaded onto the west aspect of the 'wharf'. Therefore, if masonry was to be found anywhere on the 'wharf', it would be most expected to appear on the extreme west aspect of this feature. Trench 2 measured 3m east-west by 1m north-south and was cut over the west flank of the 'wharf' (see figure 42; plate 34).

Falling gently to the west, the topsoil measured ca .25m (see figure 45). Beneath was a layer of colluvial subsoil similar to that in Trench 1, consisting of two cobbles as well as a large quantity of pebbles/sand. Beneath this layer was found pleistocene silts. Unlike Trench 1, no artefacts were recovered from Trench 2.

Interpretation. It seems that the layer described as 'subsoil' may have been the occupational level during the Roman period. Indeed, only Roman period artefacts were recovered in this context. That they were found within this level in Trench 1, and not in Trench 2 is explained most easily by the fact that a smaller area was opened in Trench 2. As for the feature (context 3) cut into the pleistocene silts of Trench 1, the recovery of solely Roman period artefacts, the lack of surface undulation, and the pottery sequence combine to suggest that the proposed pit was dug and back-filled in the Roman period. Further, charcoal lining the bottom suggests a pit perhaps used for burning rubbish.

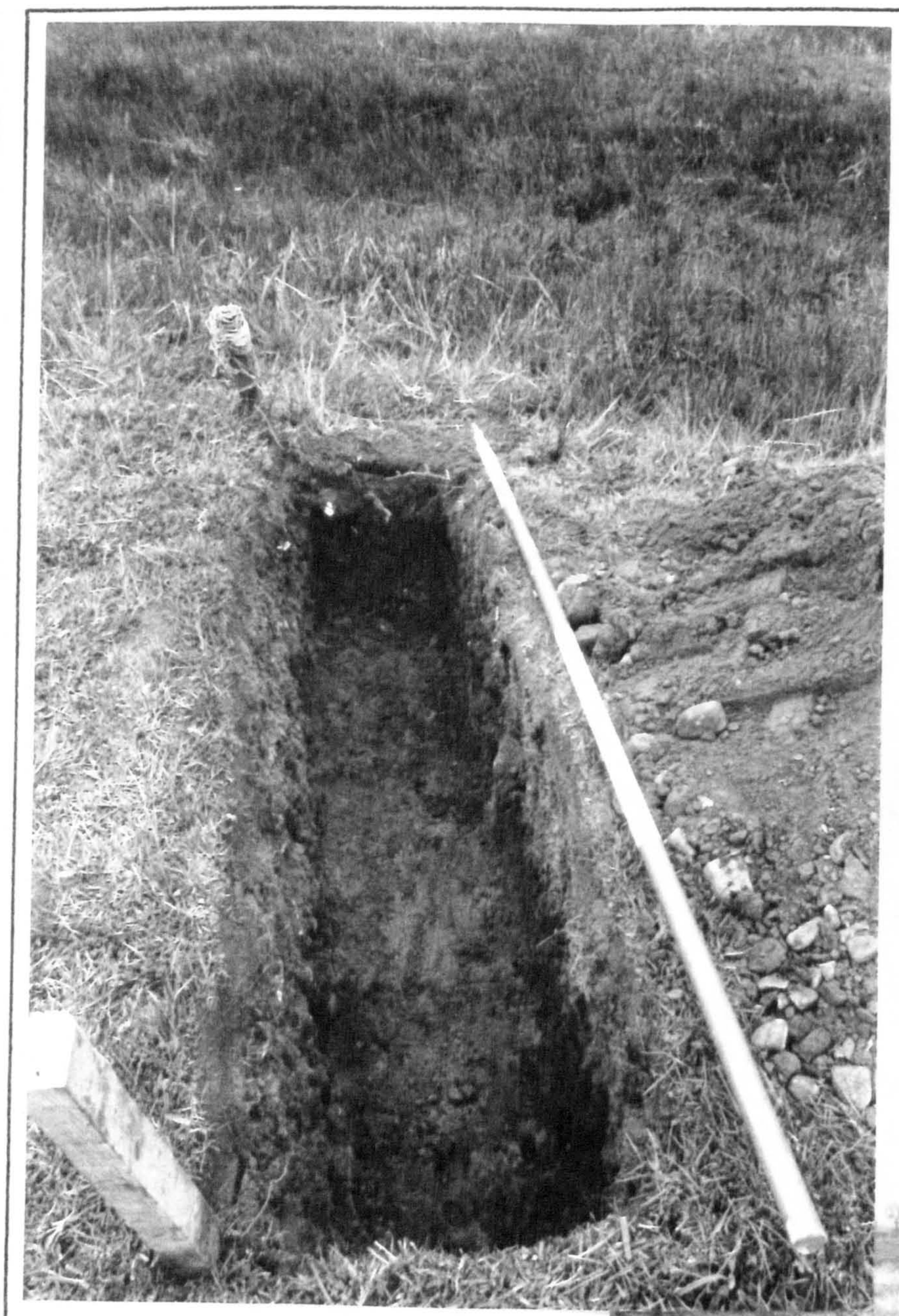


Plate:**34** Overview of Trench 2 in 'groyne' at Risingham, east facing west, with Bell's 'E' (1844) in background.

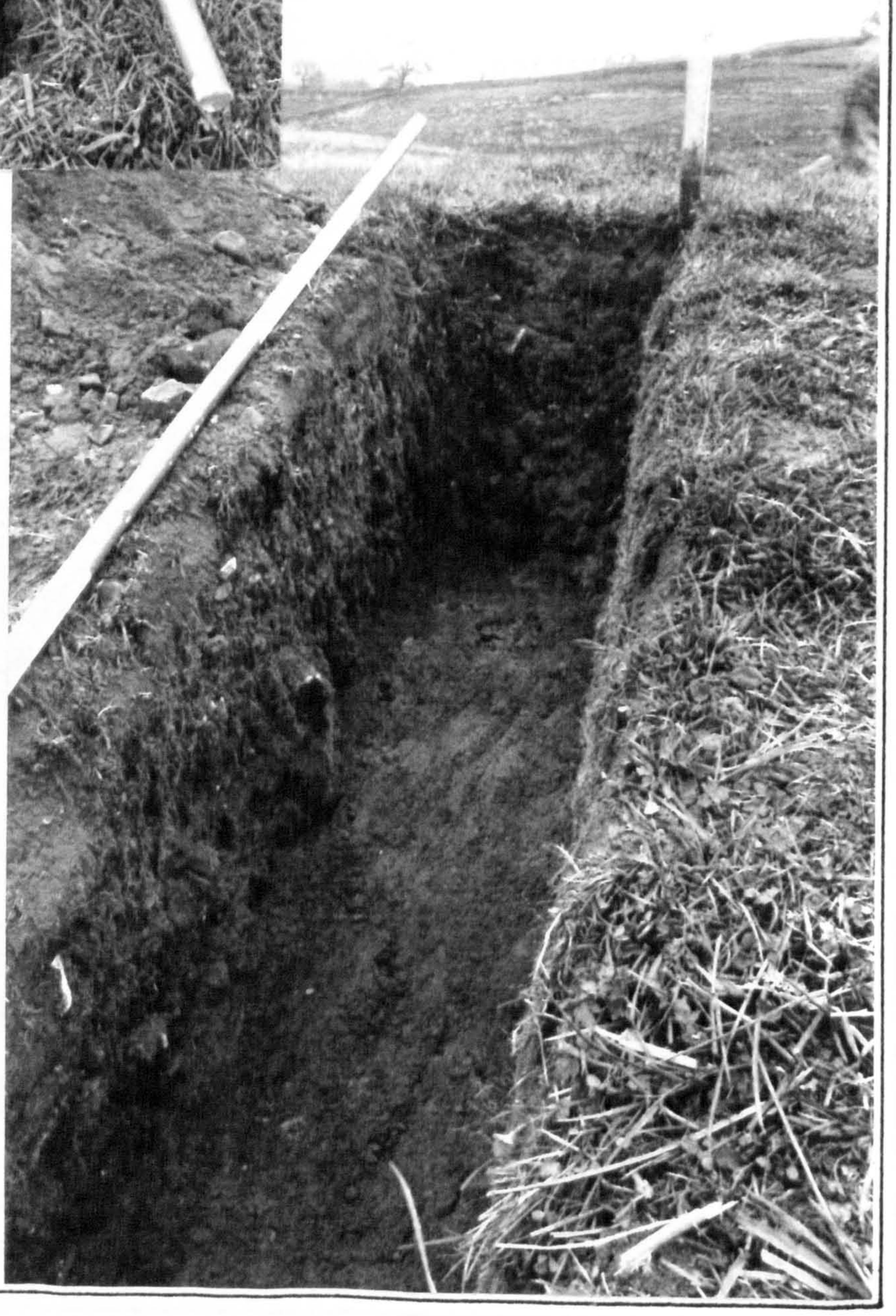


Plate:**35** Partial section of Trench 2 in 'groyne' at Risingham, west facing east.

None of Bell's "vast quantities of stone", nor any other Roman period structure was found. The occupational level lay over, and the proposed pit was cut into the underlying pleistocene silts. Within these contexts, very few stones larger than gravel were found, and of these, the largest can be described as no more than uncut, natural river rubble, 7cm across.

The complete lack of evidence for a Roman period structure from the numerous probes taken across the feature, as well as from a large trench cut in the middle of the so-called 'weare', and another bisecting its western flank, argues conclusively against Bell's conjecture that this feature was a Roman structure built to hold back the force of the River Rede. At the same time, neither was the feature a Roman 'barge wharf'. Rather, when viewed from a distance north of the fort, the feature can be appreciated as part of a large, flat and relatively-dry soliflucted till platform formed from the discharge of silts at a point where the Chesterhope Burn empties into the Rede, which was eventually cut by post-Roman channels. Overlooking the bridge, a bend in the river, perpetual swamps and water-logged palaeo-channels of the flood-plain, this site provides a classic bridge-head fort platform (discussed below, 6.3).

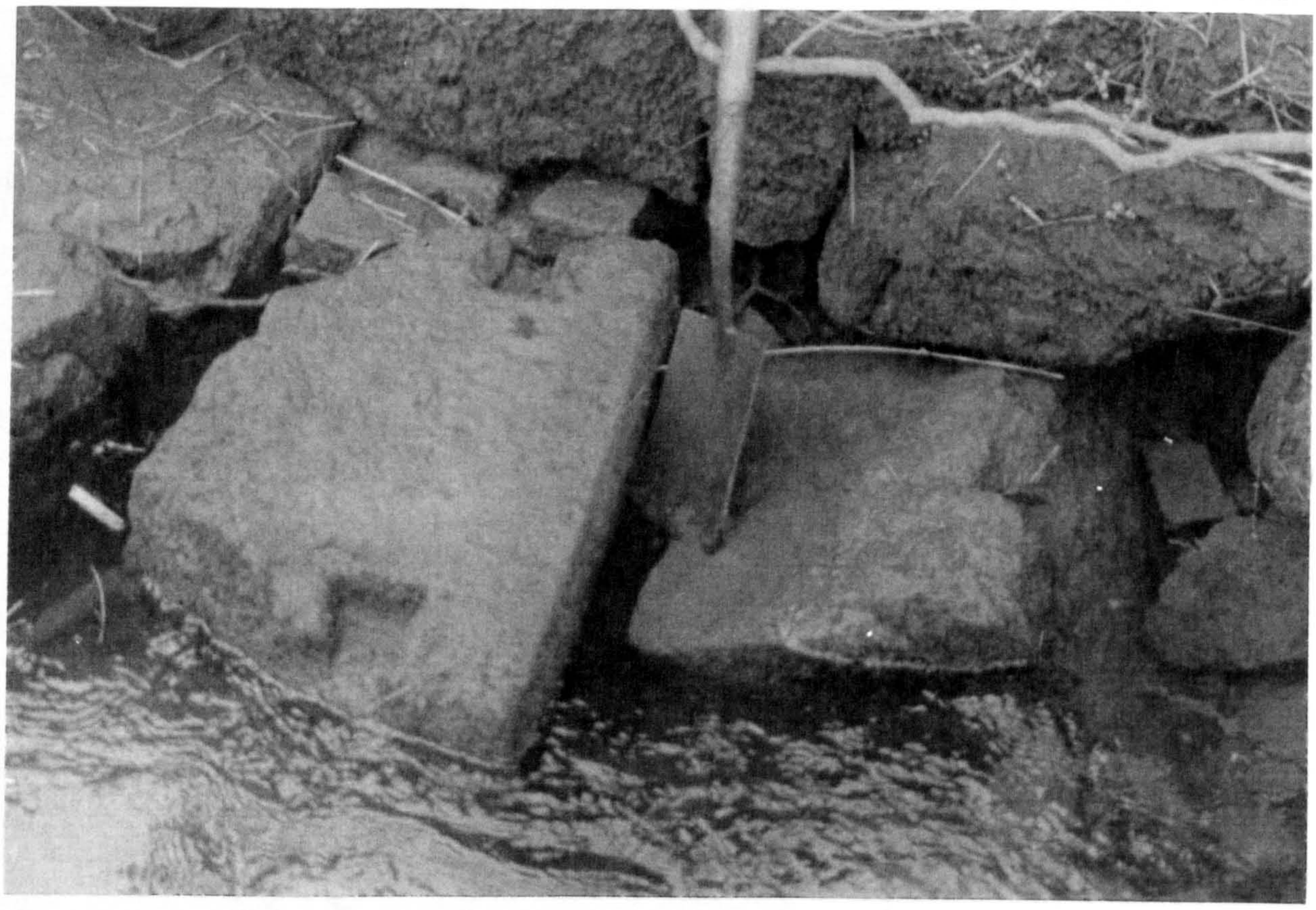


Plate:36 Masonry in Chesterhope Burn; remains of Selkirk's 'dam'.

Plate:37 Dere Street 'Embankment' at Risingham; north facing south.

Other references attribute the masonry in Chesterhope Burn (see plate 38) to a Roman bridge crossing the Rede. After a flood had washed away the area north of the Chesterhope Burn, J Hodgson sketched (1824) a number of rectangular and dove-tailed stones lying at the confluence of the Chesterhope Burn and the Rede. The structure recorded is six stones long, three stones wide (1824). In addition:

> "The foundations [of the bridge] laid bare two years since [are] laid bare now. The many stones of the buttresses at the ends of the Bridge thair had a hole in the centre of the upper surface, I think of the lower bed too for the purpose of putting a strong square oak pin in to prevent their being moved off their beds singly. Riddle says they were dowelled together with oak. When the Rede a few years since tore away a part of the meadow on its north side it exposed two tall upright stones standing at 12 feet [3.66m] distance ... They were about 8 yards [7.3m] apart."

Bidwell and Holbrook (1989, 114) argue that these stones probably formed part of a bridge abutment, with two columns standing on either side of the carriageway on the north abutment.

Indeed, lewis and cramp-holes, although prolific in the bridge-works at Chesters and Corbridge, have not yet been found in Romano-British river dam contexts. In addition, a Roman bridge to carry Dere Street over the Rede is expected at this point. It could be that the road was carried to the bridge from the south over an embankment (see plate 37):

> "...that Roman engineers had also visualized these conditions [river action] is shown by the great embankment which carries Dere Street to the bridge-head, well above these floods which have long since washed away the bridge and corresponding causeway to the north."
>
> Richmond, 1936, 193

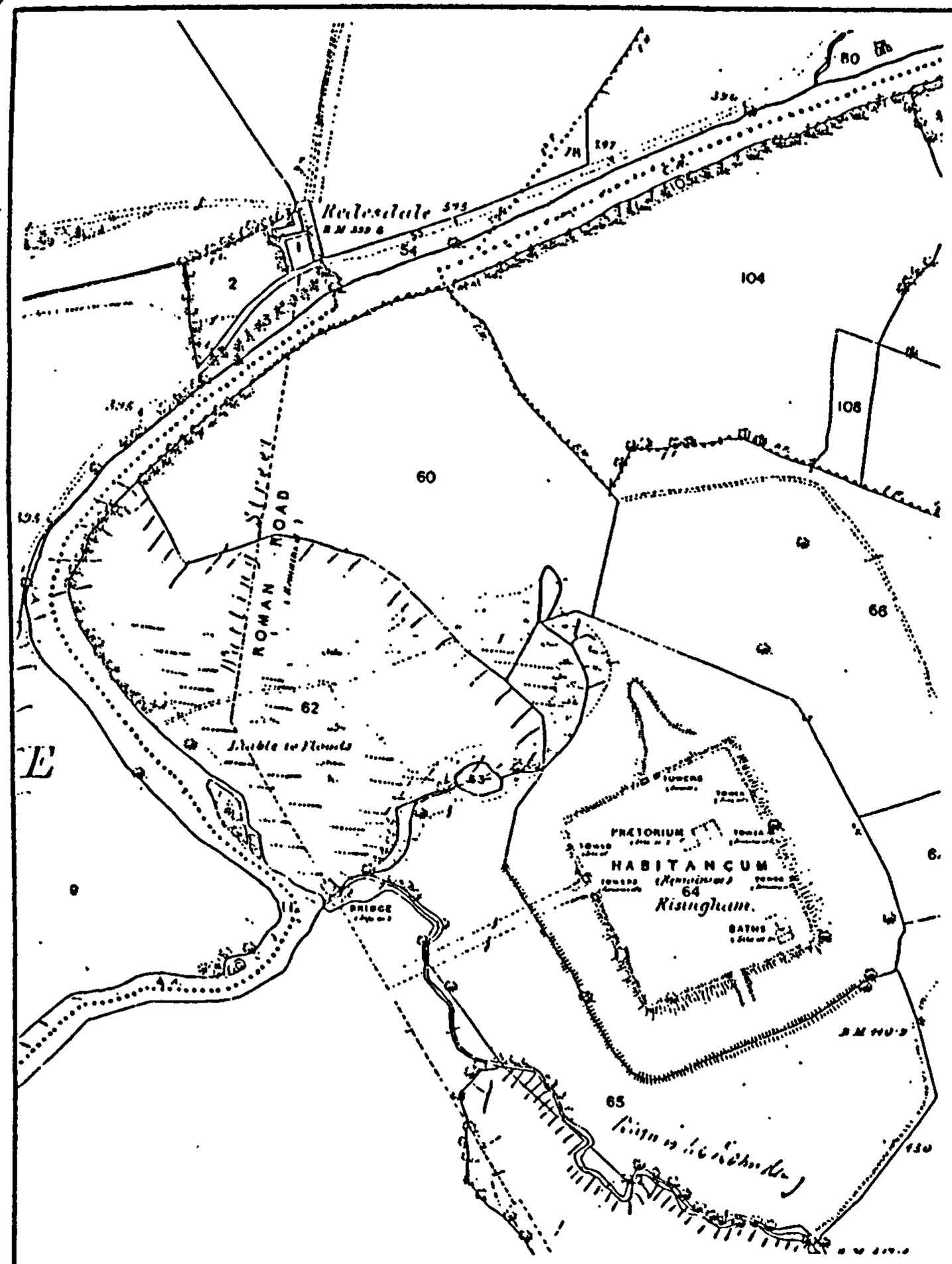


Fig 46: Risingham, OS 1862, 6 inch.

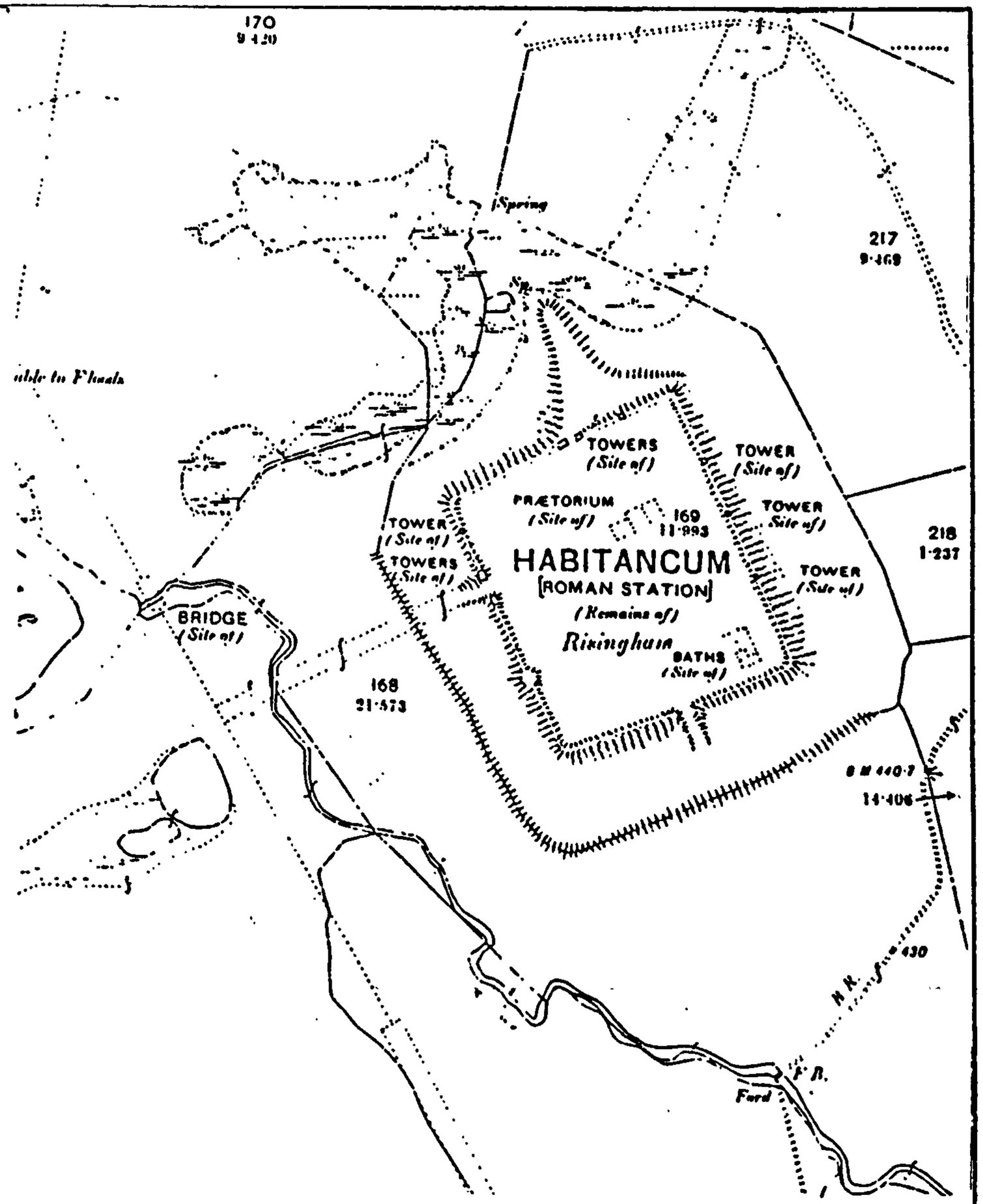


Fig 47: Risingham, OS 1896, 6 inch.

Loading Dock

The description of the area where carts were loaded for the distribution of supplies to the local area is vague.

> "The Roman road, Dere Street passed between the fort and the river, and would have had to either cross the canal loop or run around the wharf. It is very likely that carts were loaded here for distribution of supplies to the local area."
>
> Selkirk, 1983, 156

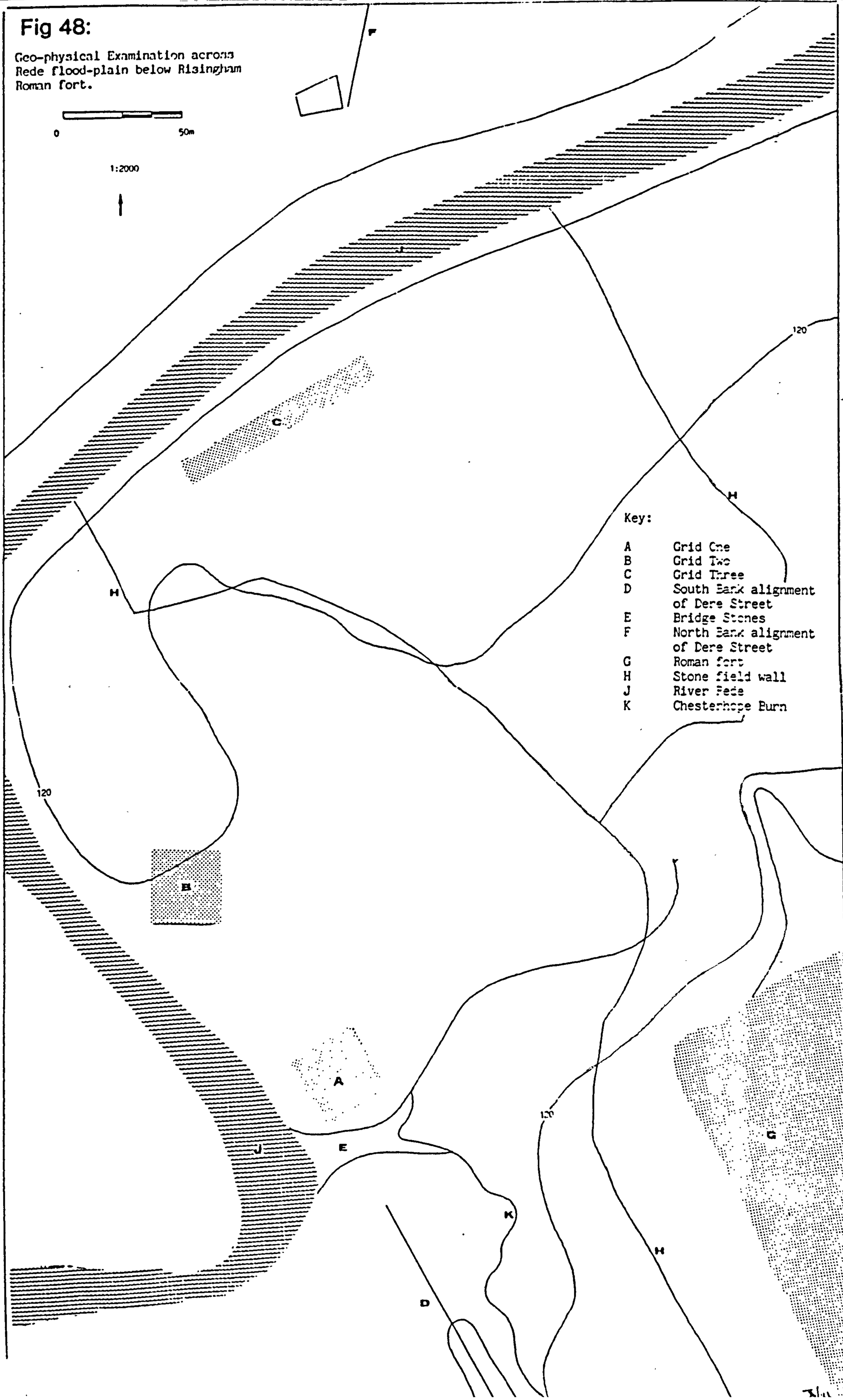
In order to "run around the wharf", a diversion of Dere Street east from its northern alignment south of the fort would have been necessary. Supporting the Piercebridge formula is Bell's drawing of 1844, which has Dere Street diverting east at Chesterhope Burn (see figure 38). Subsequently, however, the editors of early edition OS maps depicted the road running on the same alignment north beyond the burn, until it met the southern projection of the north bank alignment (see figure 46). If correct, Dere Street would not have crossed the 'by-pass canal' or passed near the 'wharf'. In order to determine the course of the Roman road as it crosses the Rede valley, a geo-physical examination was made in three grids across the flood-plain, in January and February, 1991 (see figure 48; for a full discussion, see Anderson, Rushworth, and Willis, forthcoming).

Fig 48:

Geo-physical Examination across Rede flood-plain below Risingham Roman fort.

0 50m

1:2000



Geo-physical Examination. The uncertainty of the course of Dere Street stems from the character of the valley: geo-fluvial processes taking place since the Roman period have long since covered or erased surface evidence of the Roman road. As the flood-plain is covered by relatively uniform alluvia, it was hoped that a geo-physical examination would uncover extant remains. Two systems - resistivity[1] and magnetometry[2] - were used over three grids.

Grid One. The first grid, measuring 30x30m, was placed immediately north of the Chesterhope Burn, fully encompassing the projected line of Dere Street as it descends the south bank towards the bridge stones in Chesterhope Burn. The resistivity results (see figure 49) accord with Hodgson's description of bridge-works at Chesterhope Burn (Hodgson, 1824, above). On the southern aspect of the grid are stones, indicated by the highest figures and therefore greatest resistance. Although uncertain, it is possible that this material represents extant masonry.

---

[1] The resistivity system used to collect data for this thesis involved four probes (50cm apart and penetrated ca 5cm into the surface) projecting electrical waves a maximum 3m vertically into the earth. The depth to which these waves penetrate depends upon the 'resistance' of the soil: the more resistant the template, the less electrical charge is produced. These results are recorded in units varying 300 to 1500, the higher figures representing less resistance. The highest resistant material represents stones, while the least resistant represents liquid.
[2] The magnetometry system used for this thesis involved the projection by a single 'pod' of magnetic impulses ca 3m into the earth. The difference in magnetism between sub-surface materials and the gravitational pull of the earth is measured in units, the highest figures for which represent the greatest difference between the magnetism of the feature and gravitational pull.

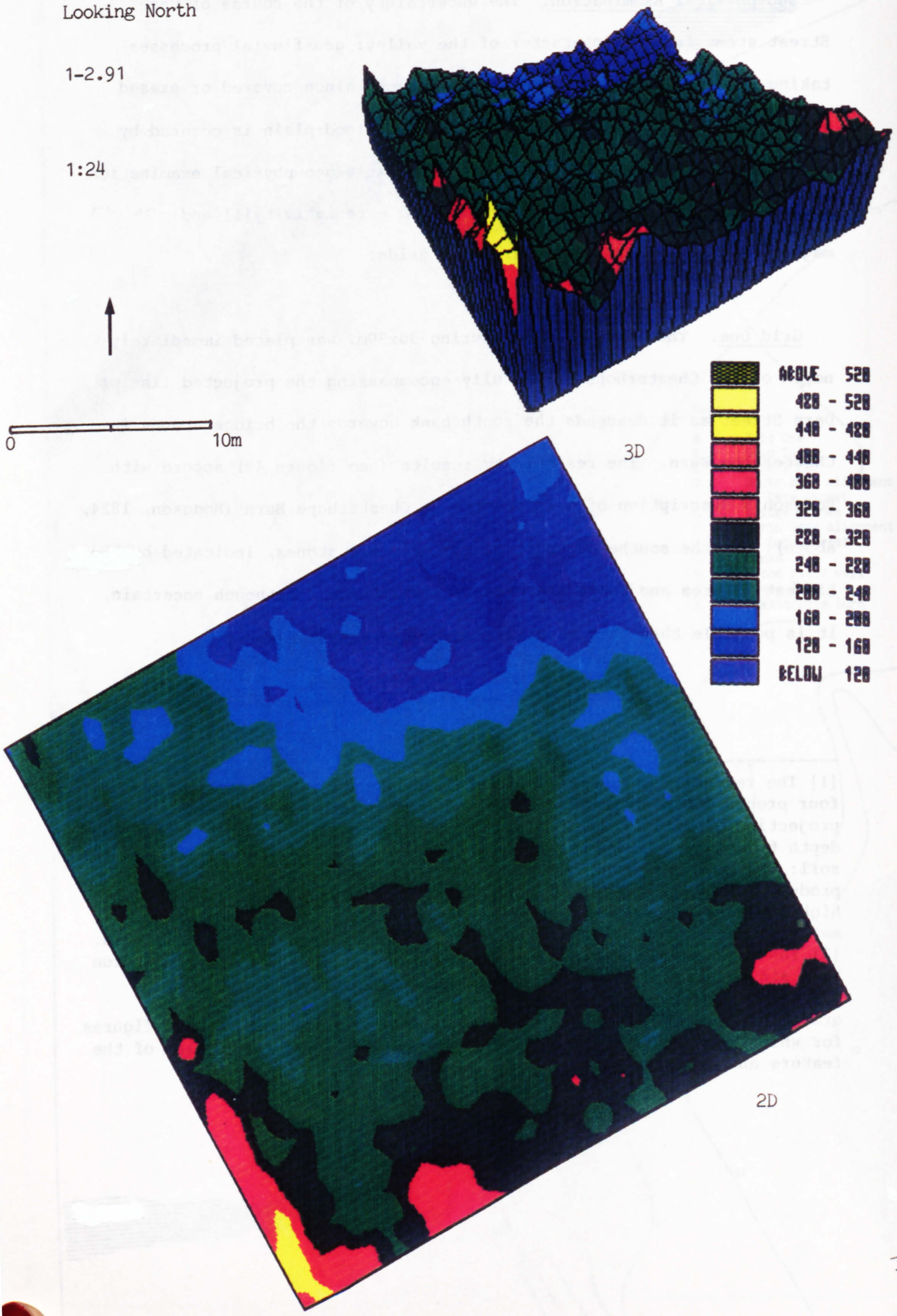
Fig 49:

Risingham Resistivity: Grid One

Looking North

1-2.91

1:24



A/91

Moving north in the grid, the material becomes less resistant. The northern extremity of the grid comprises material of least resistance, in this case most likely water-logged river alluvia (pers comm Dr C W Titman). This material may represent the course of the channel noted by Hodgson cutting the bridge-works north of the Chesterhope Burn. Having filled with river alluvia, this palaeo-channel would have been susceptible to penetration by water, especially in the winter months. Either the road north of the bridge was washed away with the bridge by the palaeo-channel (Richmond, 1936, 193), or the road surface was more than 3m below the present surface and therefore beyond the range of our equipment.

The magnetometry survey revealed in the southern aspect a concentrated area of charcoal, metal, or stone (see figure 50). Although it is difficult to be certain, in view of the resistivity survey results, it is possible that this too represents bridge stone (pers comm Dr C W Titman). Across the rest of the grid, again, material with a higher magnetic attraction seems to lie within material of relatively less attraction. Agreeing with the resistivity survey results, it may be that this latter material is alluvia deposited in the 19th century palaeo-channel, and the higher magnetic material is that which remains of the bridge-works (pers comm Dr C W Titman).

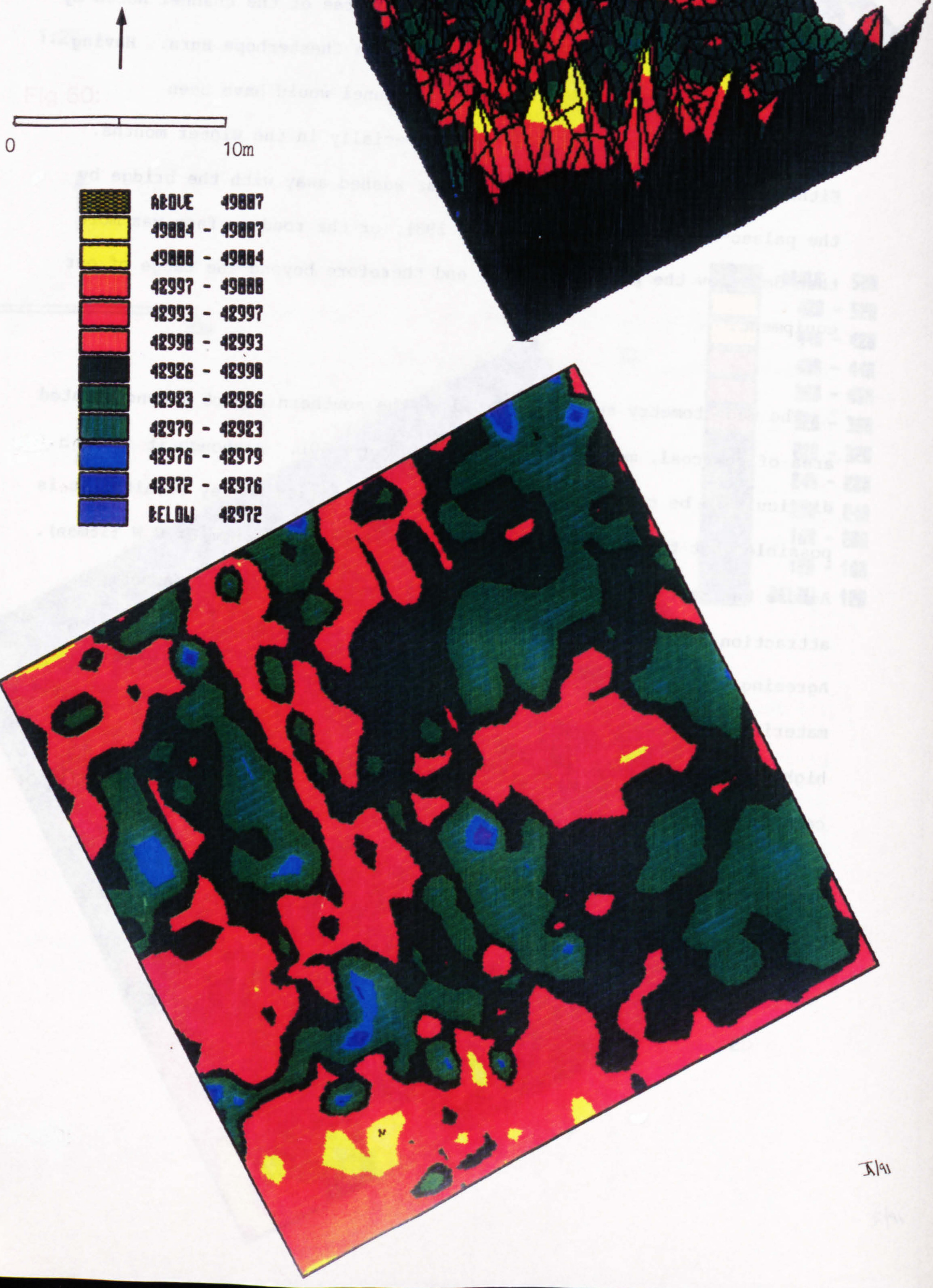
Fig 50:

Risingham Magnetometry: Grid One

Looking North

1-2.91

1:24



JA/91

Grid Two. Grid Two also measured 30x30m, and was set up at what was judged the intersection of the south bank line, with the north bank line descending south into the valley. As in Grid One, resistivity results suggest a palaeo-channel running through the south aspect of the grid (see figure 51). Given the character of other palaeo-channels across the flood-plain (see figure 40), it is possible that this is a northern meander of the same channel as that described in Grid 1, cut perhaps at the beginning of the 19th century. On the north-west and north-east aspect of the grid are what seem to be stones within the alluvia.

The magnetometer survey shows a broad line of higher magnetic pull running north on the east aspect of the grid (see figure 52). In the northern aspect, this line is characterized by material of the highest magnetic pull, perhaps indicating stone. It is thus conceivable that the road is represented in the south-east and north-east aspects. As stone only appears in the north aspect, it is possible that the palaeo-channel ran only through the south aspect: thus the stone of the road was preserved in the north aspect and removed in the south.

Grid Three. It was hoped that Grid Three, measuring 30m east-west by 9m north-south, would reveal the line of the road as it descended south from the north bank into the valley. The resistivity results (see figure 53) show a long line of high resistance running east-west. To the south of this is a long channel of less resistant material. It is possible that this high resistance represents a clay pipe-line set into the alluvia for drainage purposes, and the channel to the south that into

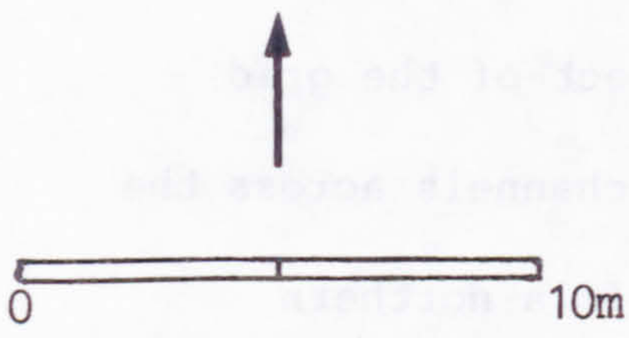
Fig 51:

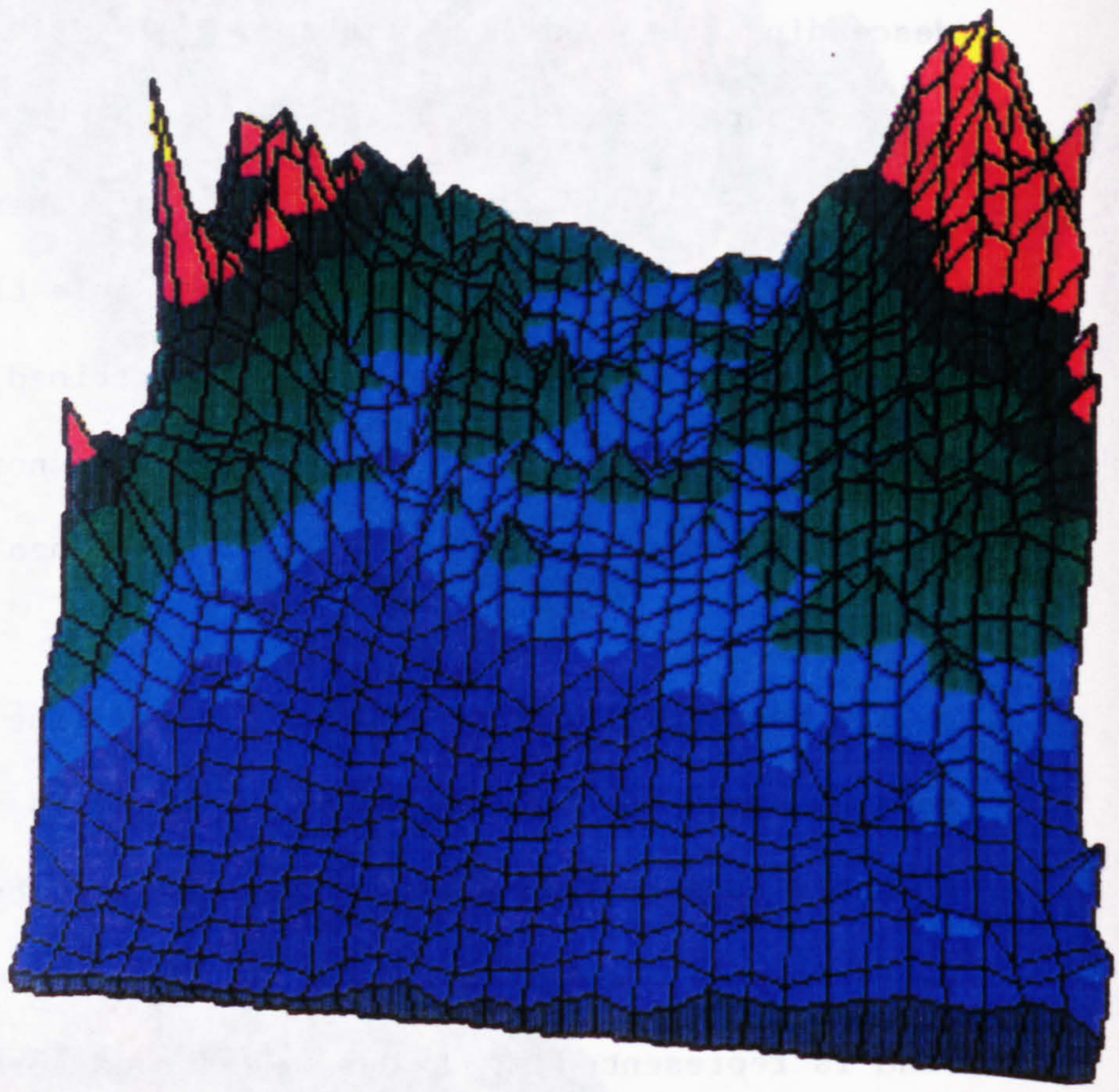
Risingham Resistivity: Grid Two

1-2.91

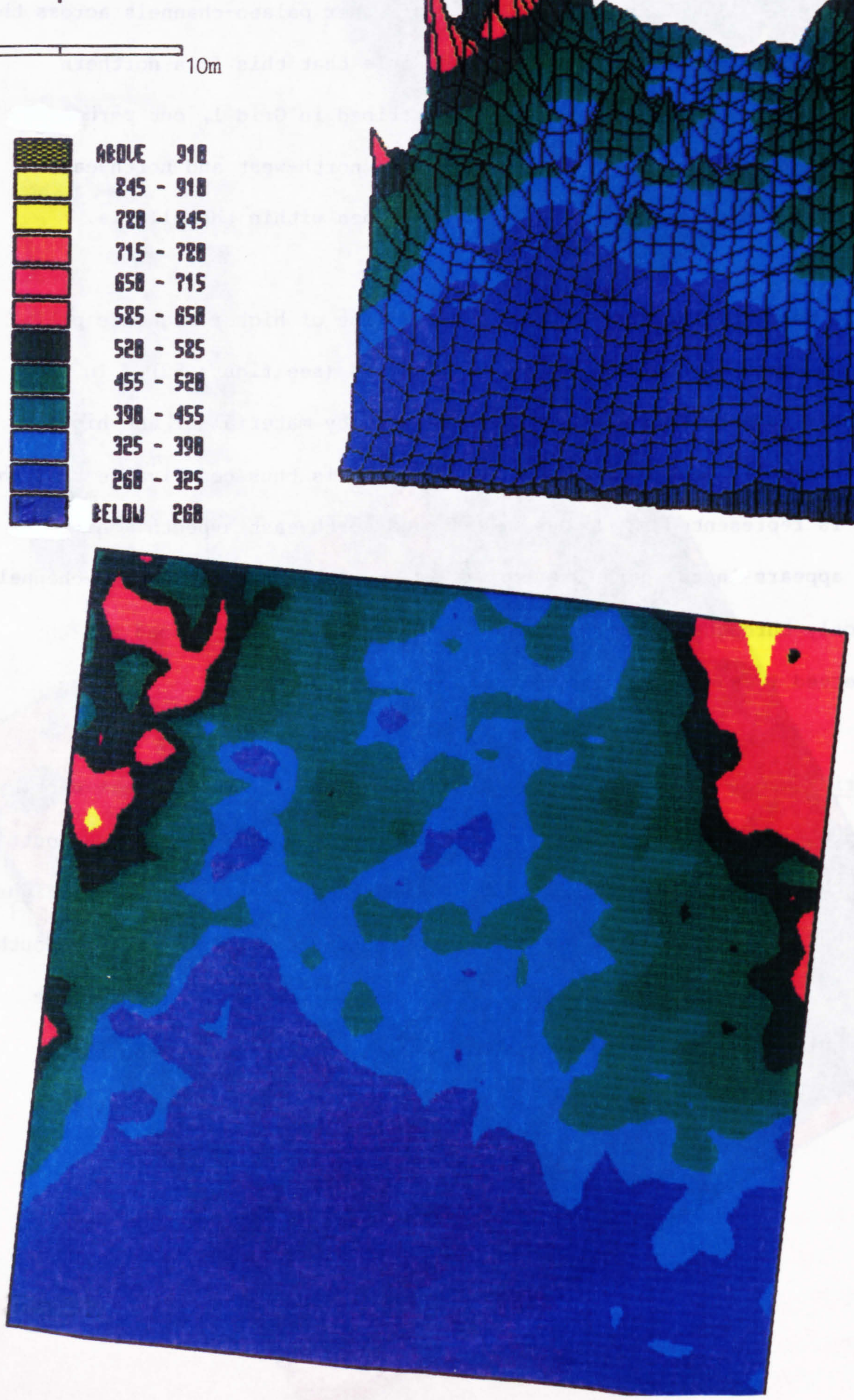
Looking North

1:24





3D



2D

3/91

which the pipe-line was set (pers comm Dr C W Titman).

Unfortunately, no indication of the Roman road was found in Grid Three. If the above interpretation is correct, it is likely that the excavation of the channel has distorted any remains of the Roman road passing through. On the other hand, the equipment may not have been sufficiently sensitive to penetrate deeply enough through the sediments over the Roman road. Yet again, it is also conceivable that all remains of the road have been washed away by river action at some point since the Roman period. However, given our very wide grid, it is very unlikely that the road course was missed.

Interpretation. Resistivity surveys of Grids One and Two probably show one or perhaps two large meanders cutting across the grids. These meanders and accumulated deposition within and over them go a long way to explaining why no surface remains of the road exist today in the valley of the Rede. The results also seem to bear out the location of the bridge-works noted by Hodgson in 1824. The resistivity results suggest that such works were removed most probably by a combination of the encroaching 19th century meander and human endeavor (as recorded by Hodgson, 1824), in all but the south aspect of the grid, immediately north of the Chesterhope Burn. This is also suggested by the magnetometry results.

Further, it seems certain that the road did not veer east across the flood-plain immediately north of the bridge, but continued along its

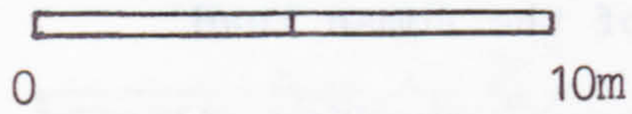
Fig 52:

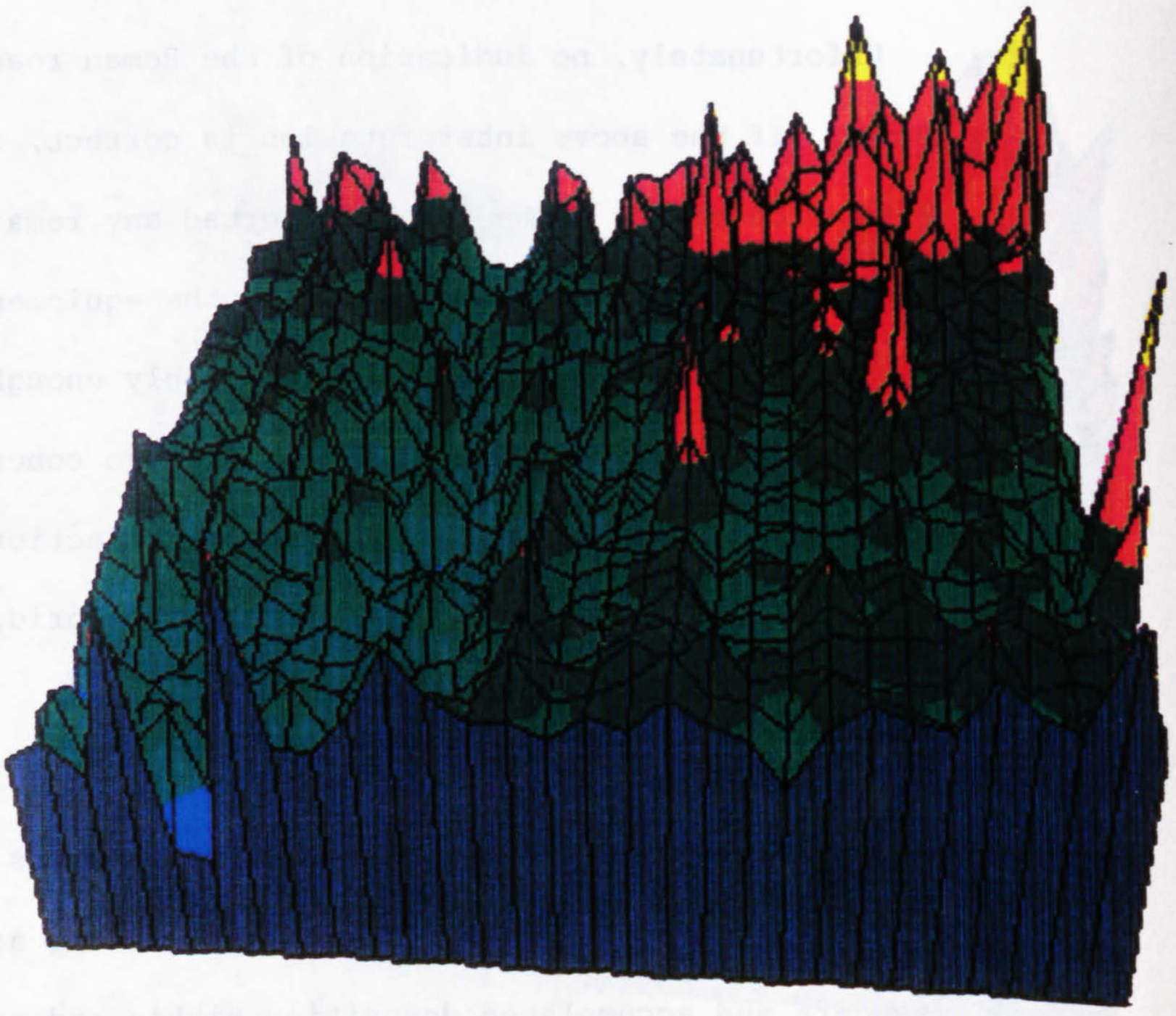
Risingham Magnetometry: Grid Two

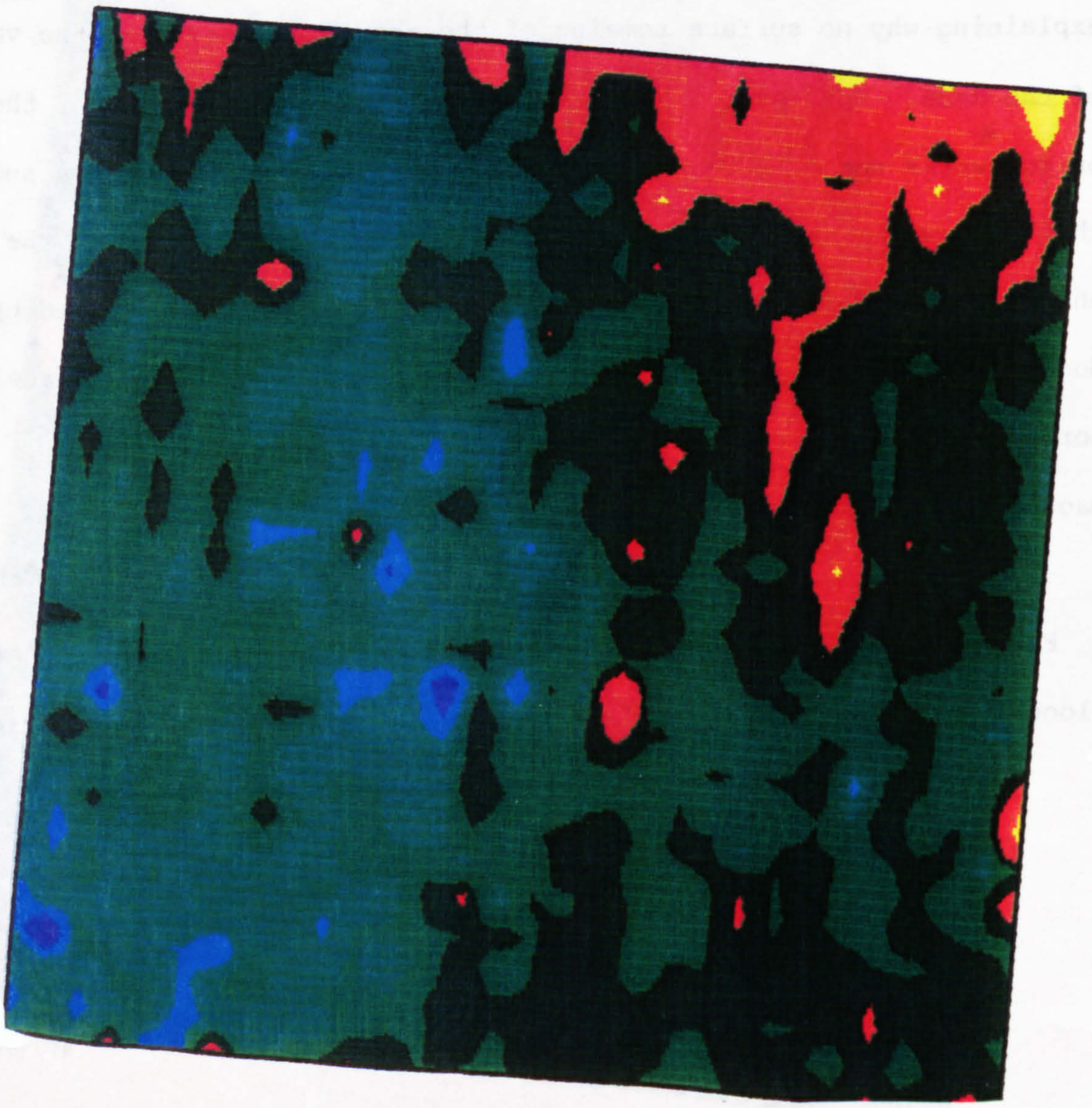
1-2.91

Looking North

1:24







3D

2D

A/91

alignment from the south bank and over the bridge across the valley, at least to the point of Grid Two. The slightly magnetic material in the east aspect of the grid, running north to what appears to be stone on the magnetometry survey in the north aspect is parallelled in the resistivity survey. If the 1:24 and 1:2000 plans of the Grid Two magnetometry survey (see figures 52 and 48) are aligned, it becomes apparent that the projected line of the road from the south runs from the south-east aspect north to either the north-west or north-east aspect of the grid. If the former, the turn of the road is somewhere north of Grid Two. However, it is also possible that the great mass of stone in the north-east aspect of Grid Two represents the turn of the road to the north-east. If so, this would agree with the projected alignment of the road running up the north bank beyond the modern course of the River Rede.

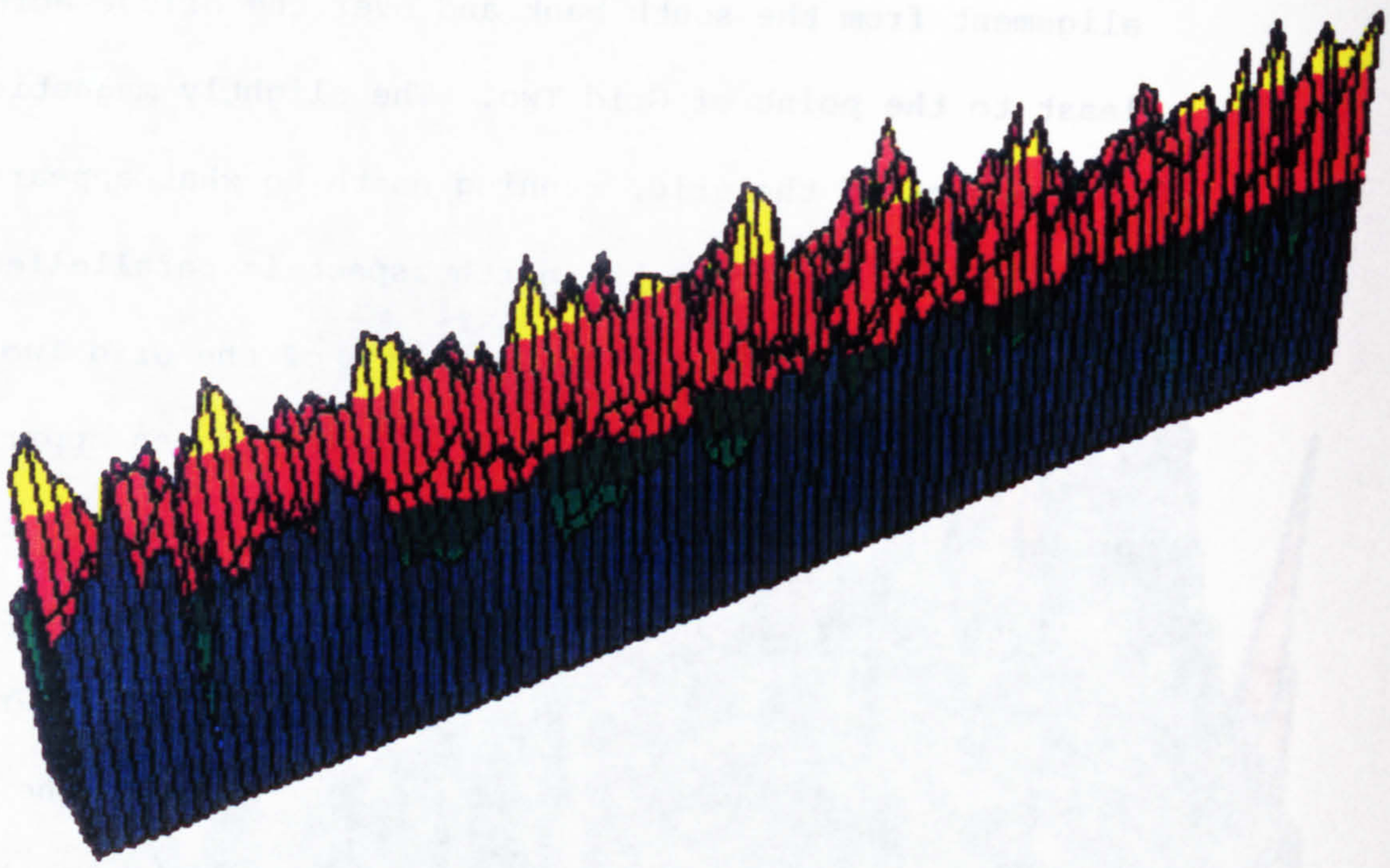
In short, as it is reasonably certain that the road continued north from Grid One to at least Grid Two, it seems that the road could not have "run around the wharf", as has been argued (Selkirk, 1983, 156).

Fig 53:

Risingham Resistivity: Grid Three

1-2.91

Looking North

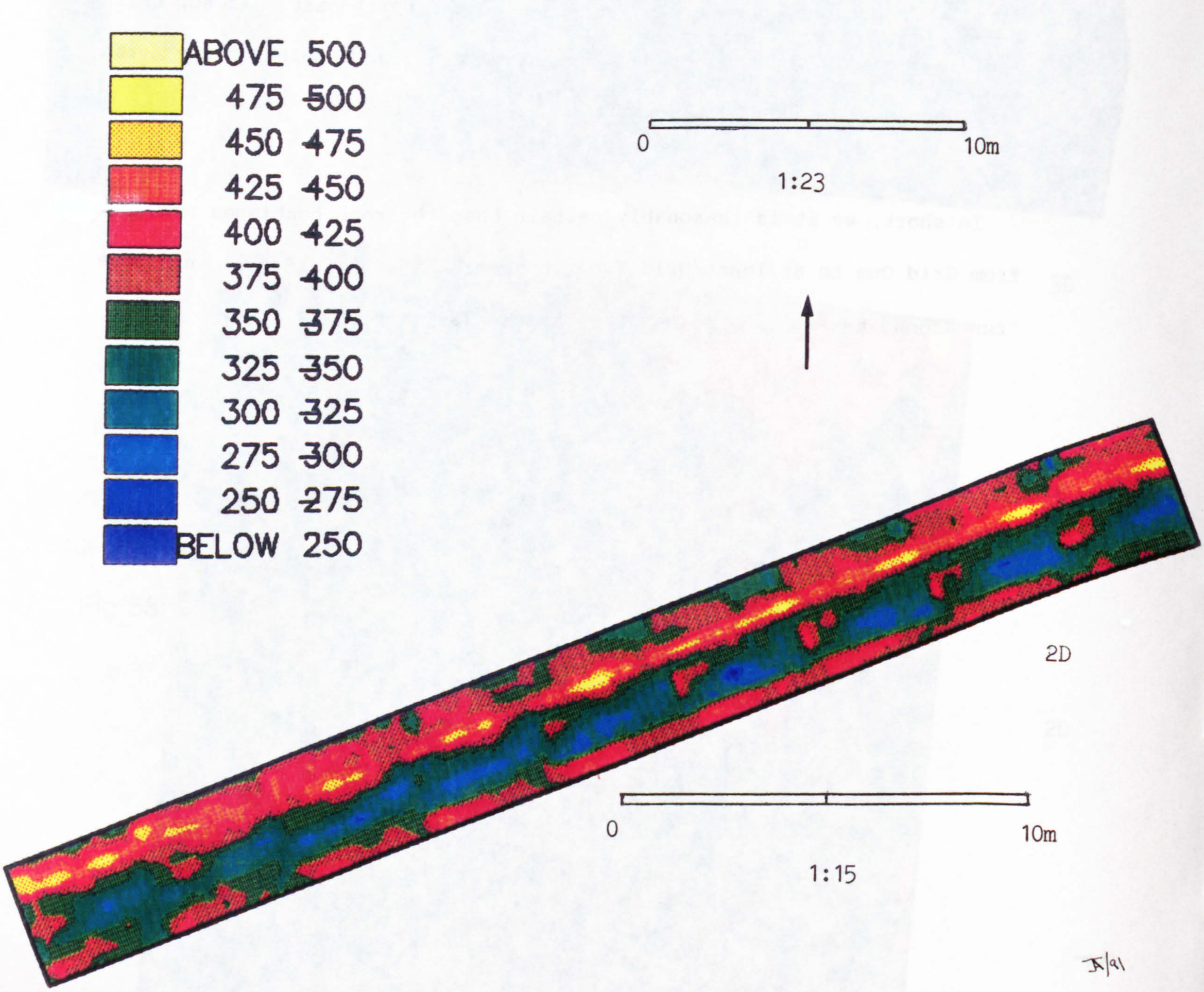


3D

0 10m

1:23

ABOVE 500
475 500
450 475
425 450
400 425
375 400
350 375
325 350
300 325
275 300
250 275
BELOW 250



2D

0 10m

1:15

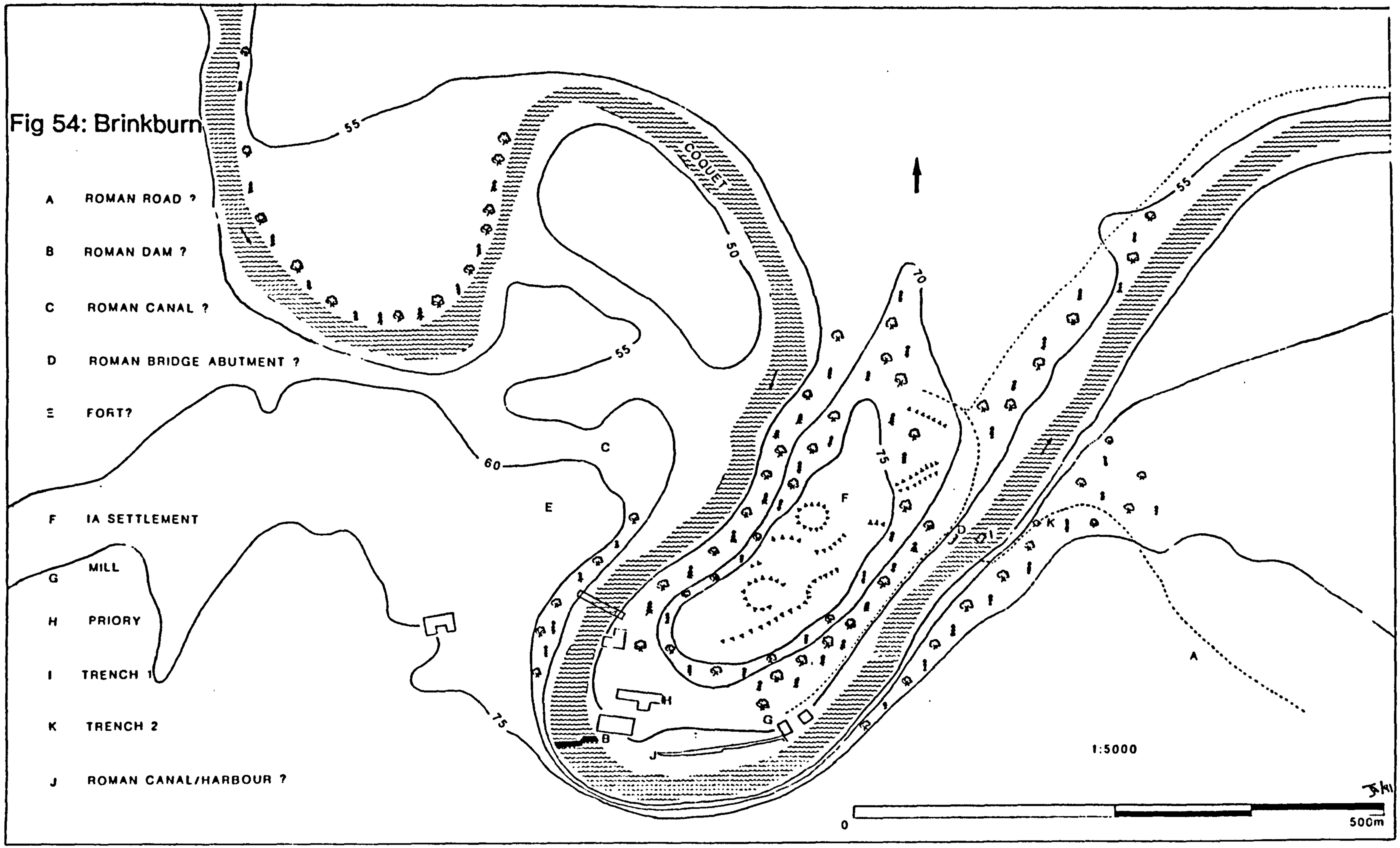
A/91

5.1.3 Conclusion

No evidence exists for any of the four Piercebridge components listed at Risingham fort. The 'by-pass canal' is a post-Roman palaeo-channel of the once turbulent and active Rede. The 'barge-wharf' is the remains of a terrace or platform upon which the fort was constructed, and was formed by the Rede's trimming of two loops in the northern area of the terrace, the westernmost of which, at least, was cut in the post-Roman period. Excavation has proved that the feature does not contain a Roman structure. The 'dam' masonry more likely comprised part of the bridge carrying Dere Street over the Rede west of this 'bridge-head' fort (Richmond, 1936, 195), whereas evidence for a loading-zone is totally non-existent. In total, nothing suggests that barges supplied Risingham from South Shields along rivers developed according to the Piercebridge formula.

Plate:38 Risingham Roman fort; oblique view from north; NY 8986; Cambridge University, 1967.

Fig 54: Brinkburn



5.2 BRINKBURN

Situated in an 'S'-shaped curve in the River Coquet (NZ11 98), the site at Brinkburn lies ca 1km west of the Devil's Causeway's Coquet crossing, 45.8km from Corbridge, ca 50m above sea level, and 34.1km from the Coquet mouth. Today it includes a Priory,[1] mill works and race, and traces of bridge abutment and pier. North of the Priory are ruins of an Iron Age promontory fort, and to the west, what have been interpreted as fish ponds. Brinkburn is also listed as a Piercebridge formula site, with a Roman road, bridge, fort, canal fronting the fort, canal/barge harbour and dam downriver, and Roman period occupation on the hill above the Priory (Selkirk, 1983, 158-9; 1986).

5.2.1 Evidence Supporting the Piercebridge formula

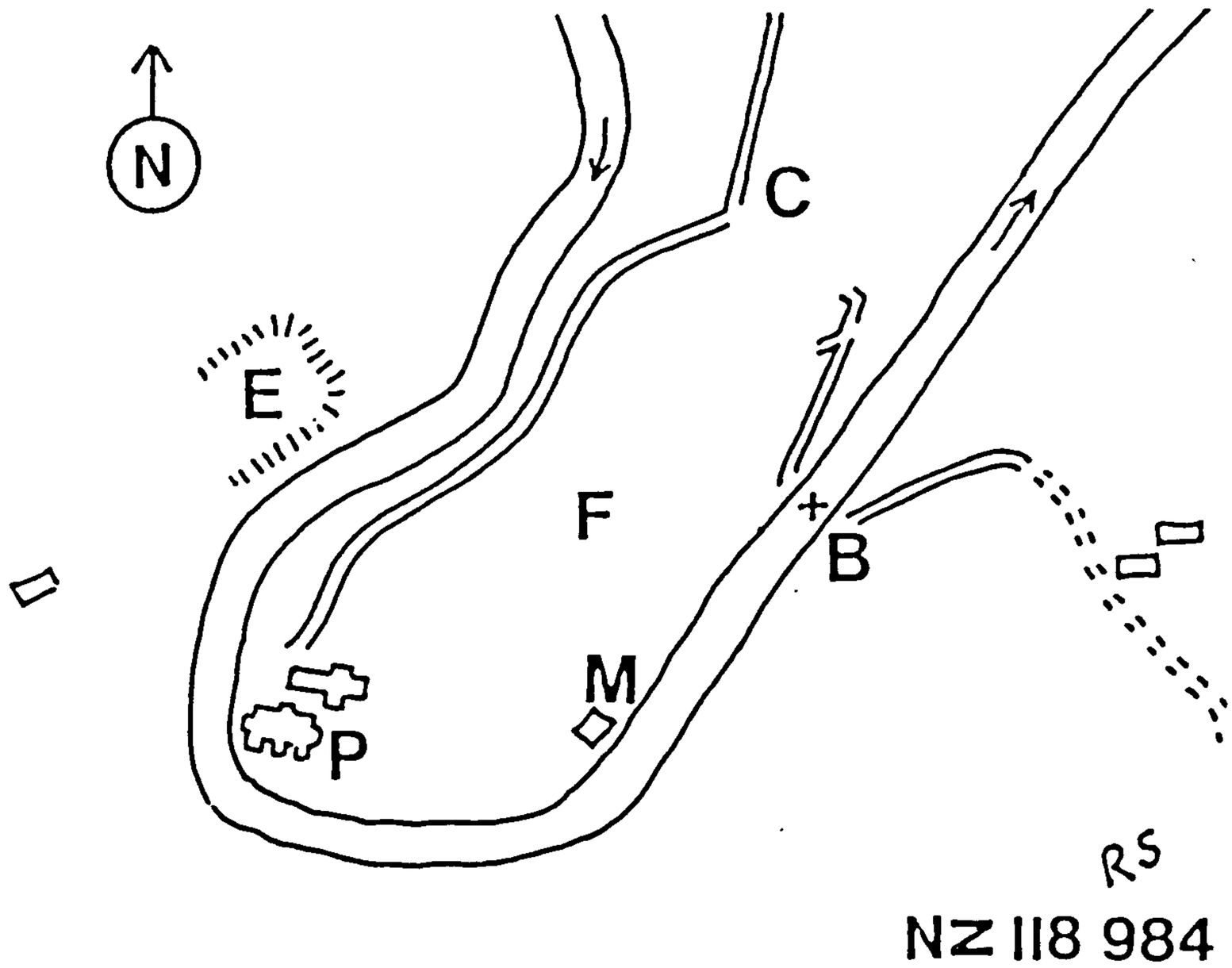
A Roman road has long been argued to branch west from the Devil's Causeway south of the Coquet to meet a bridge on the river to the east of Brinkburn Priory. Perhaps the earliest reference is by Sir David Smith, [2] in ca 1820:

> "The Devil's Causeway also leads down to the river (where the Roman bridge stood) in order to maintain its general direction,

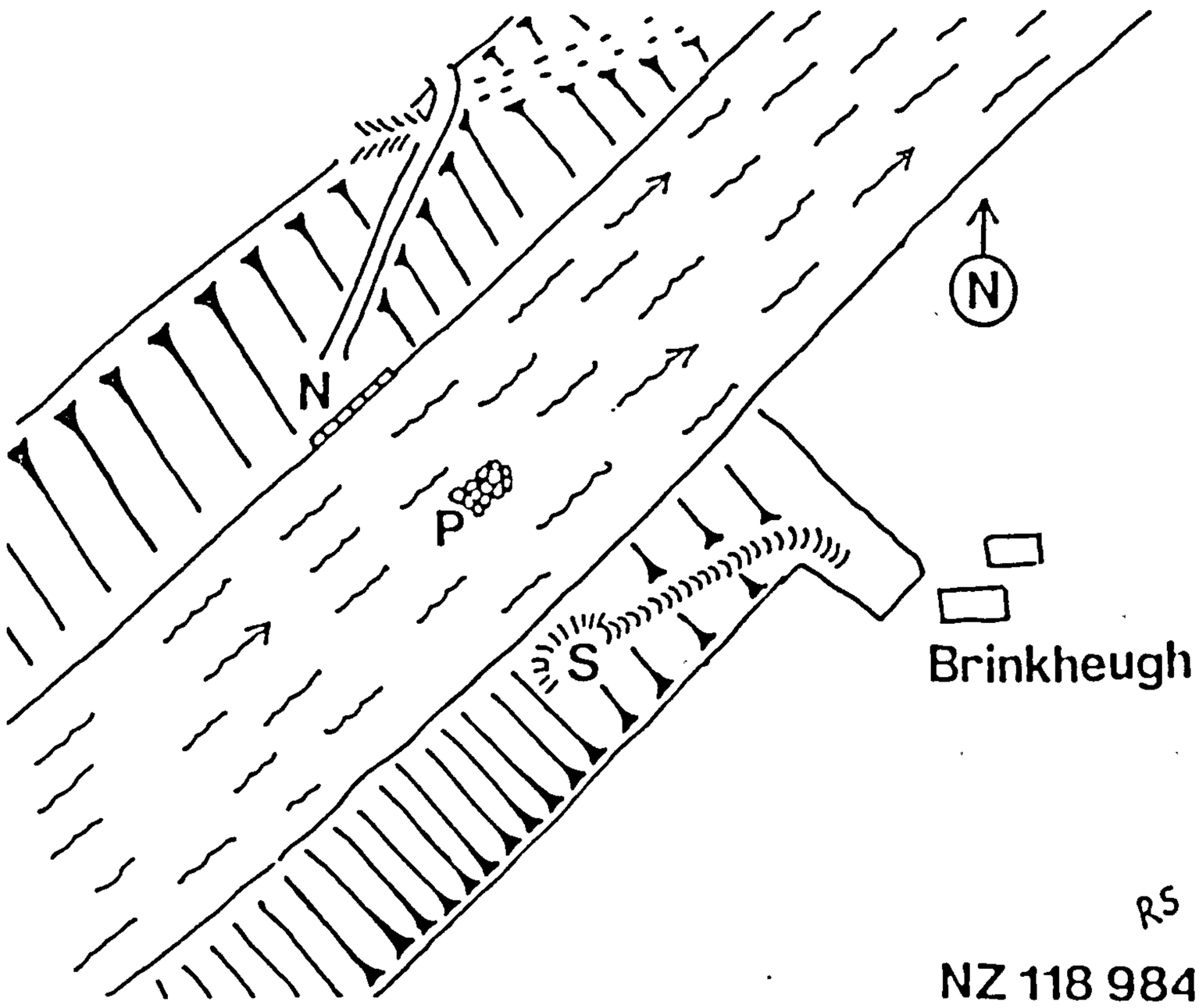
---

[1] It was built by William Bertram I of Mitford in 1130-35 for Augustinian canons. The house was dissolved in 1536, and after considerable decay, was restored in 1858-65.
[2] The date of the publication of Camps and Castles is uncertain: '1820' is estimated by J C Hodgson's (1903, 454) reference to Smith writing "about eighty years ago".

Fig 55: Brinkburn according to Selkirk, 1986.



B = site of Roman bridge M = Brinkburn Mill P= Brinkburn Priory
F = Iron Age promontory fort E = rectangular earthwork with rounded corner
C = public car park for Priory



N = northern abutment of bridge; S = southern abutment
P = base of pier

and one of the abutments is still to be seen on the northern side of the river Coquet."

MacKenzie wrote a little later (1825, 494):

"The branch of Watling Street, or Devil's Causeway, that takes an easterly direction from Portgate, crosses the river Coquet a little below Brinkburn Priory."

A track running down the north bank of the Coquet towards the bridge is a "mirror" image of the southern angled terraceway, and therefore a continuation of the road from the south bank (Selkirk, 1986, 5):

"The road displays all the Roman characteristics - it has a steep gradient (far too steep for Medieval wagons and carriages), it also has a typical Roman agger (a marked camber) and it is double-ditched with the occasional kerbstone peeping out from the thick grass covering. I followed the agger for two thirds of the slope down to the river and then lost it in the heavy undergrowth and fallen trees."

As for the Roman bridge, D Smith wrote (ca 1820):

"When the water is low, the foundation of the spot, or rock, upon which the two arches were thrown, is to be seen. This place is between the mill and the first hedge."

MacKenzie echoed this appraisal (1825, 494):

"The remains of the piers of the Roman bridge are perfectly distinct when the river is low, particularly the ashlar work on the north side, covered with elm trees."

A mound on the south bank and stonework in the opposite bank represent the bridge abutments, with a base of a pier still visible "in the middle of the river" (Selkirk, 1986, 6):

"The cement between the stones of the pier-base is typically Roman with sherds of pottery and glass as well as the normal ingredients. The stonework of the northern abutment has the normal Roman feathered tool marks and lead has been run between the stones."

Plate **39**
Tooled stone under
Brinkburn abutment.
North Bank.

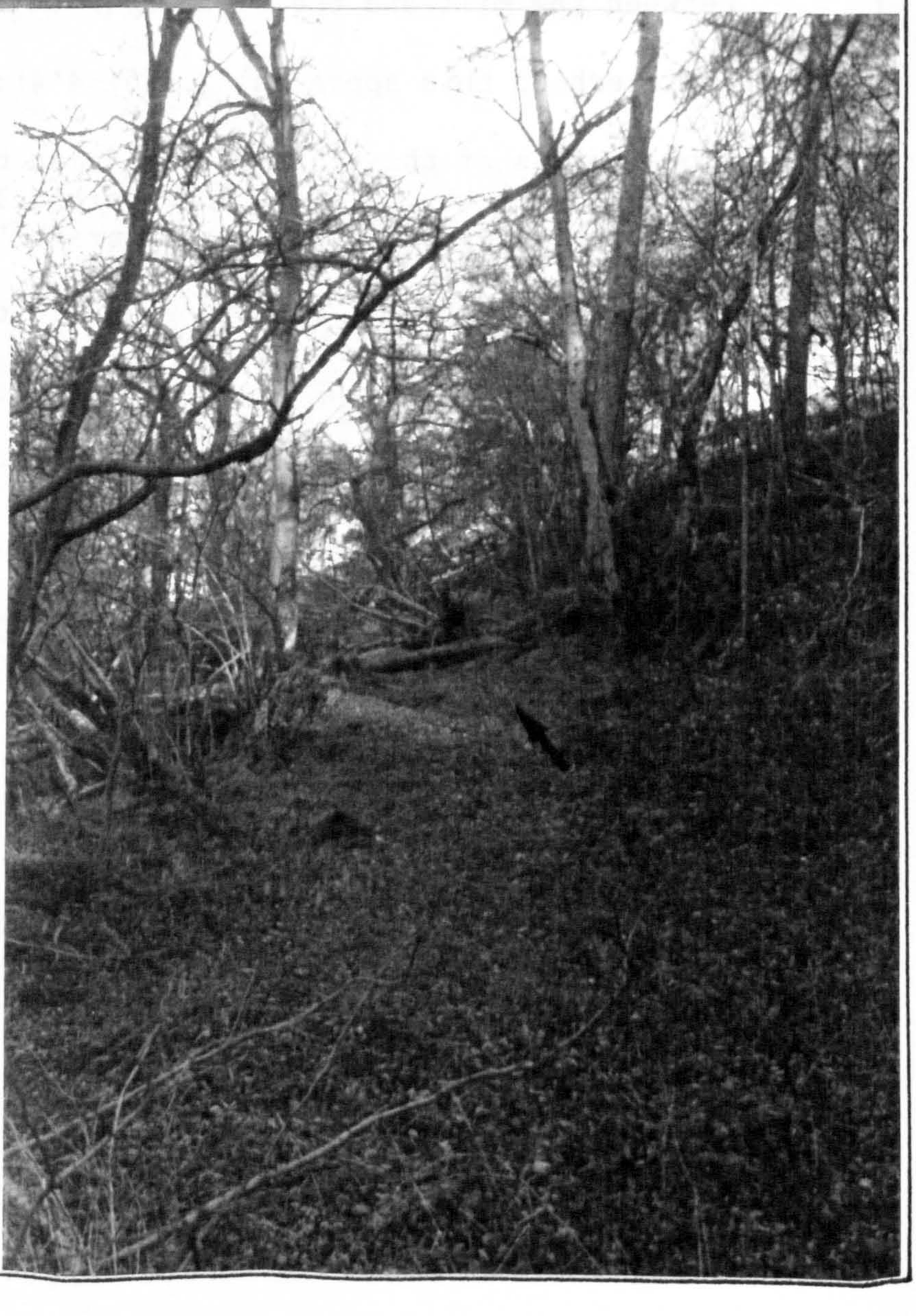


Plate **40**
Hollow-way
on south bank
of Brinkburn
Bridge.

Across the Coquet west of the Priory and within a bend of the river (NZ1160 9875) is the rectangular platform of a Roman fort (Selkirk, 1983, 159). The platform has two "very prominent rounded corners at the north end" and was man-made, formed by shaping an old river bank (ibid.). The fort was serviced by a canal running east-west to the north of the fort platform. Again this was man-made, "and in no way could it be a mill channel or fish run. It was far too vast. Thousands of tons of soil had been removed" (ibid.).

It has long been held that a Roman occupation was located on the hill above the Priory (Smith, D, ca 1820; MacKenzie, 1825). Selkirk argues (1986) that although this is an Iron Age promontory fort, it is "extremely likely" that it was incorporated later into a Roman period fort: Iron Age forts have circular huts in them, he contends, while MacLauchlan's plan reveals rectangular marks inside the fort (see figure 60).

A barge canal originally occupied the site of the later Medieval mill-race: this channel was of a "vast" size and stone-lined, easily allowing passage of a large barge (Selkirk, 1983, 160).

The Priory mill-race dam also originally would have been Roman, allowing navigation "for a long distance upstream" (ibid.).

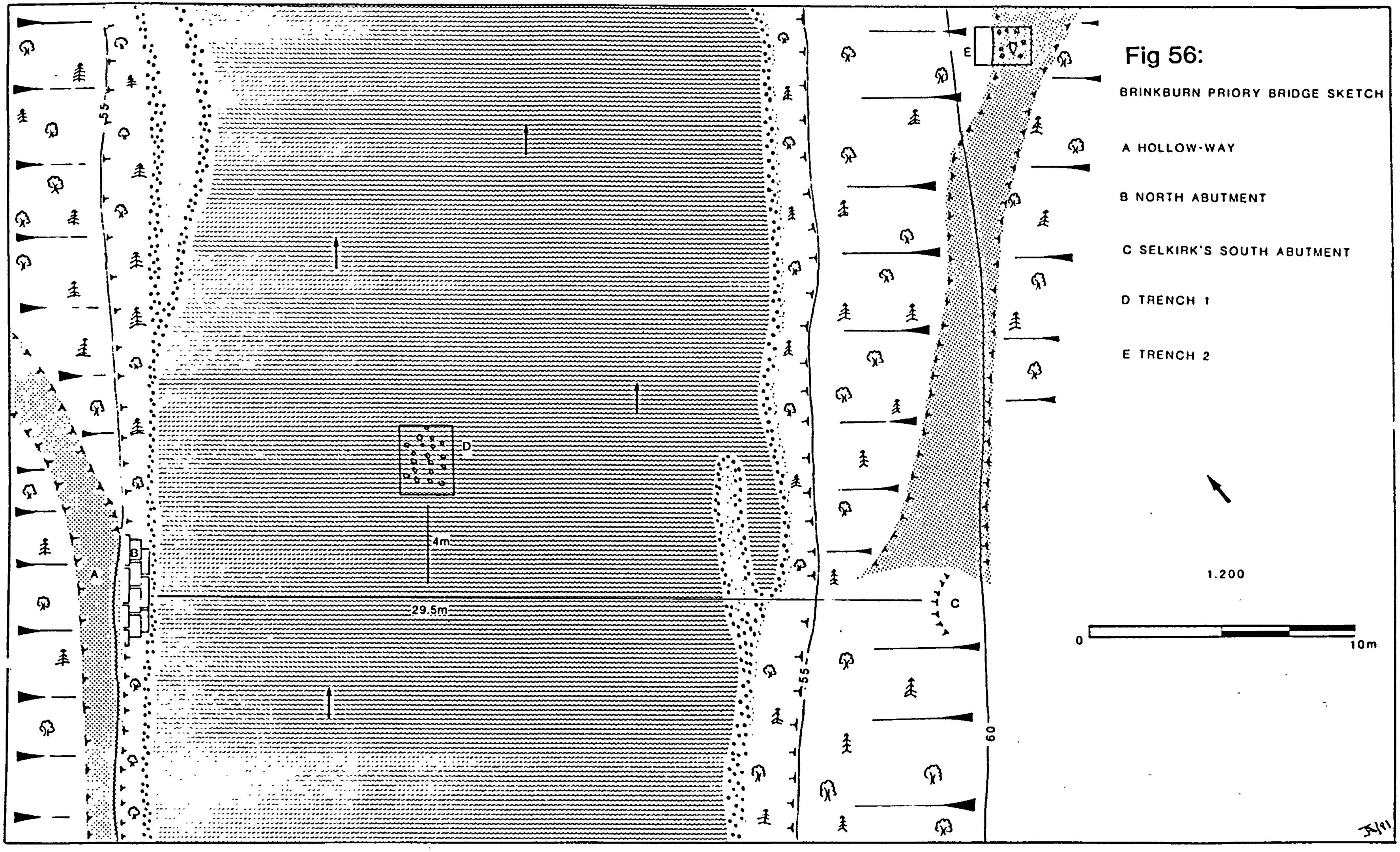


Fig 56:

BRINKBURN PRIORY BRIDGE SKETCH

A HOLLOW-WAY

B NORTH ABUTMENT

C SELKIRK'S SOUTH ABUTMENT

D TRENCH 1

E TRENCH 2

5.2.2 Evidence Refuting the Piercebridge formula

Roman branch-road

Not all 19th century antiquarians regarded the track diverting from the Devil's Causeway, or the bridge running over the Coquet as Roman period structures. For example, MacLauchlan (1864, 15) wrote after his survey of the eastern branch of Watling Street (the Devil's Causeway):

> "...the width and construction of the road, and even the remains of the bridge, did not strike us as of a Roman character, but rather as of the age when the priory flourished."

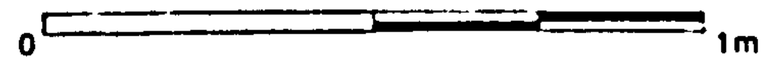
Of the antiquarians describing these ruins, MacLauchlan not only made the most extensive surveys of Roman ruins in Northumberland, he also was one of the most experienced and widely-travelled of 19th century English antiquarians (Charlton and Day, 1985, 147). His breadth of experience tempts one to favour his description over the other two accounts.

Excavation of Trench 2: the south bank track. As the track is an important piece of evidence supporting a Roman period bridge and occupation, an excavation was carried out on March 2, 1989 (see figures 56, 57, 58).[1] The excavation of the track involved digging a trench half-way along the length of the track on the south bank of the Coquet.

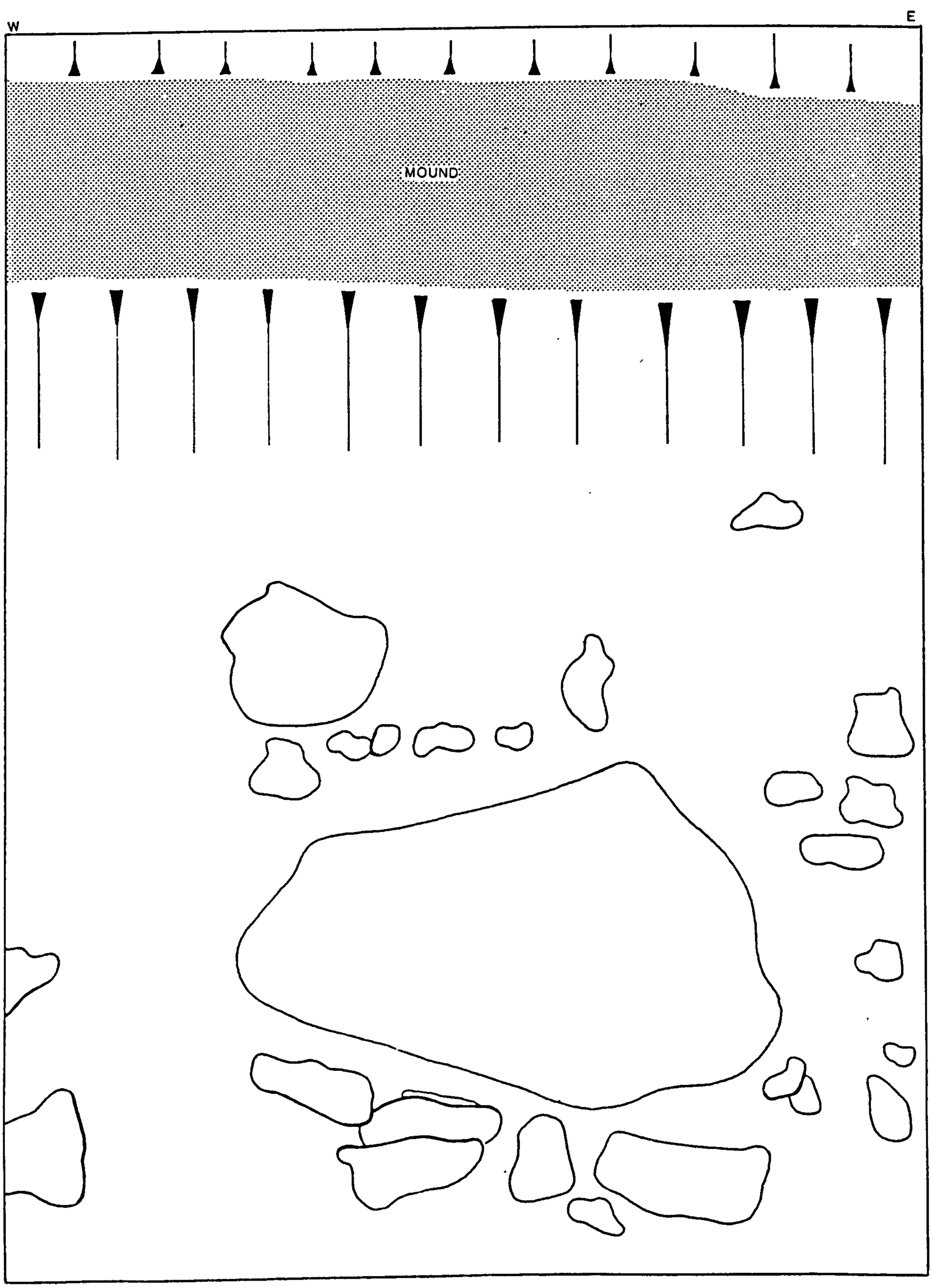
---

[1] The excavation was carried out with the assistance of Dave Cowley, and the permission of the landowner, Hugh Fenwick.

Fig 57: Brinkburn Trench 2 Plan



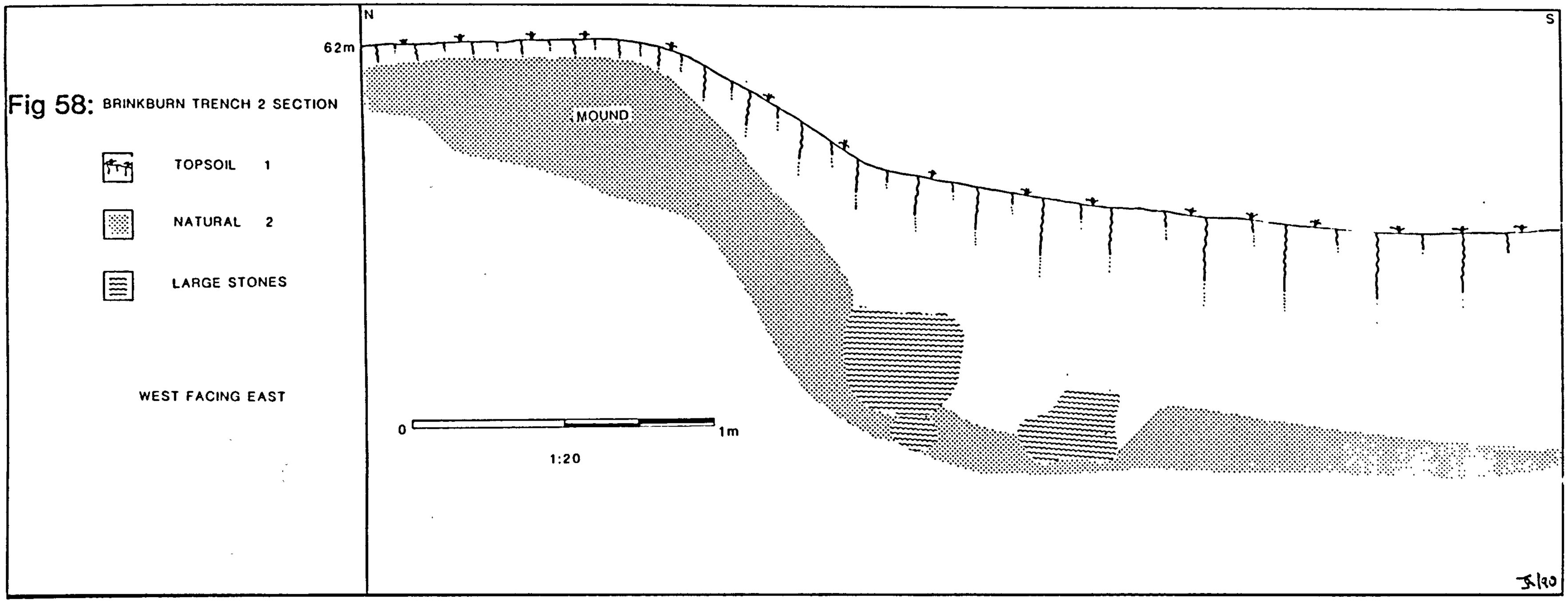
1:20



The trench was cut 1.5m east-west by 2m north-south across the north mound of the track, and extended southward to a point half-way across the track itself. Across the 'track' in the southern aspect of the trench, a layer of turf covered ca 50cm topsoil. Under this was found a quantity of uncut stone of various shapes and sizes, which can be considered 'rubble'. These stones lay above an orange-coloured natural layer excavated to a depth of 10cm, and found to be uniform throughout. The 'mound', described as a 'kerb' (Selkirk, 1986), consisted of 5cm turf over less than 3cm topsoil, underwhich was very hard, orange-coloured natural material. Again, this material was excavated to 10cm and found to be consistent throughout. No pottery, artefactual material, or charcoal was recovered from this trench.

Interpretation. The mound is representative of the general character of the river bank. That is, a thin layer of turf overlies a thin layer of topsoil, over a very hard layer of natural silts. Rather than the mound, it is the southern part of the trench across the track which is anomalous, and created by human activity. At some point, traffic began using the area south of the mound on the uphill side, and the wheels of carts gradually cut the track deeper into the natural layer (see plate 40). The unused area immediately north of the downhill traffic rut became what is now the mound. As continued use gradually deepened the track and the downhill rut, the mound became deeper on its southern and uphill aspect. Eventually, drivers presumably began to abut the wheels against the uphill side of the mound in order to prevent down-slope sliding, creating an even more vertical face to the mound.

Fig 58: BRINKBURN TRENCH 2 SECTION



Unfortunately, dating this feature is made difficult by the absence of artefactual or ecofactual evidence within the trench. Nevertheless, as discussed (above, 2.2.4; Appendix J-1), excavation has revealed certain construction techniques common to the nearby Devil's Causeway, and if Roman, this track should share the same techniques: it should be convex, rising on either side to an apex perhaps delineated with a central rib, and include sandstone blocks over a level foundation and beneath a layer of gravel, and cut stones for kerbs and paving. However, this road is in fact 'concave' and sunken into the hillside, the stone is uncut, and no gravel, kerb or paving stones were recovered.

Commercial Excavation of north bank track. Recent road-work sheds much light on the character of the 'Roman road' on the north bank. On March 6, 1991, and during the previous week, Bowden Ltd of Newcastle were preparing the entire length of the track, from the car park north of the promontory to the river, and along the north bank to the old mill houses, for a new surface. Tarmac was to be laid down to facilitate restoration and eventual habitation of the mill houses below the Priory.[1] After a back-hoe had stripped ca 50cm topsoil, the track was closely inspected from the car park to bridge abutment. Nothing but large boulders lay on top of sandstone bedrock.

---

[1] This work was carried out quite fortunately during the period of geo-physical examinations (discussed below) on the promontory above the Priory. The geo-physical team (the author, Richard Willis, and Alan Rushworth) inspected the track while work by Bowden Ltd was in progress.

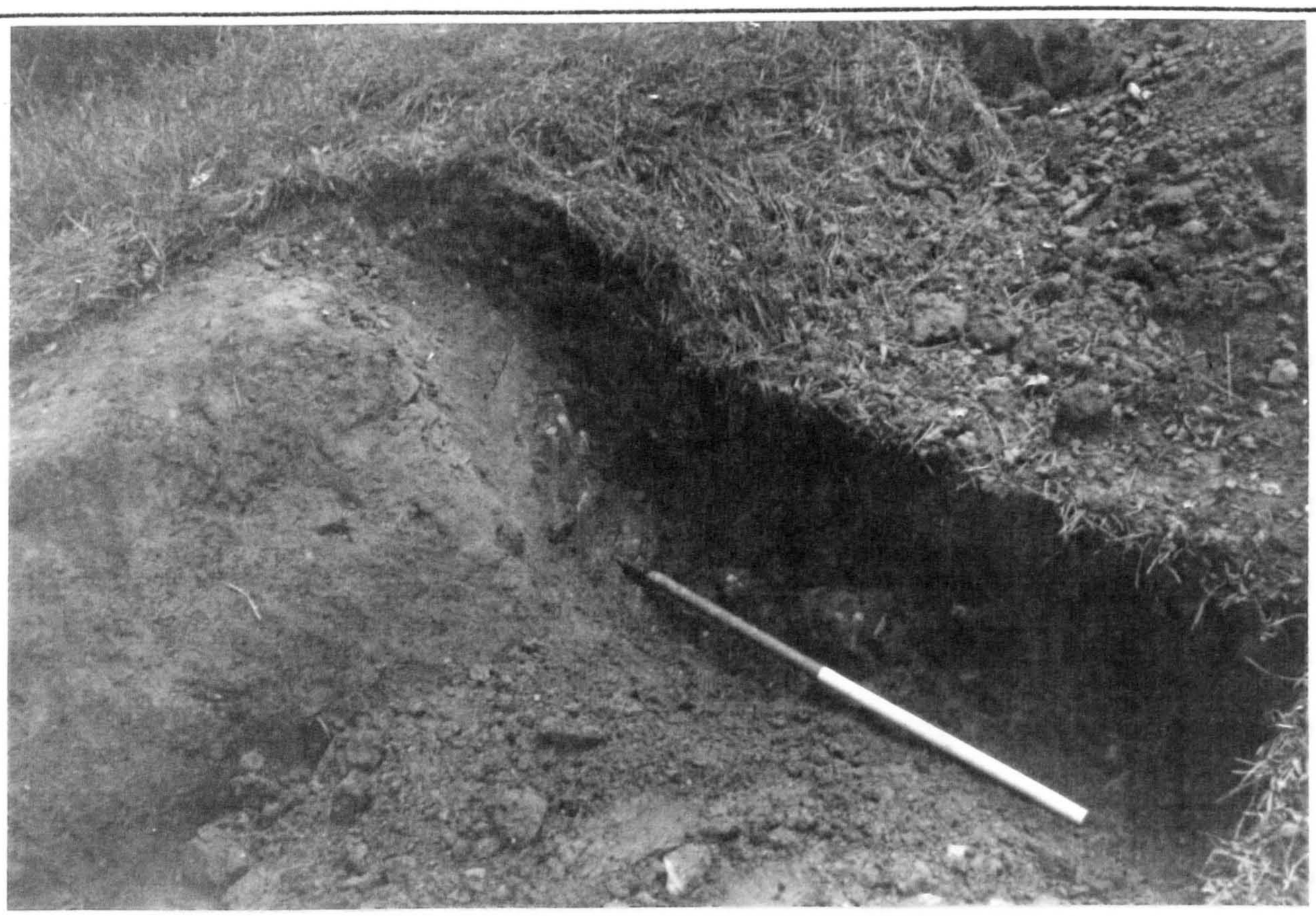


Plate: 41 Overview of Trench 2 at Brinkburn, south facing north. Note 'mound' on left.

Plate: 42 Overview of Trench 2 cut into 'track' leading down to the river, on the south bank of the Coquet, east facing west.

Indeed, over the entire week's operation:

> "We found nothing but earth covering the stones, and the stones were rubbish... they were nothing but boulders."
>
> Harry Wood, Bowden Contractors, 6.3.91

A closer look at the bedrock underlying the topsoil and boulders was afforded by additional work carried out on the road from March 6-7, 1991. On March 6, sub-contractors[1] were digging a channel through the bedrock on the extreme west side (bank-side and right when descending the track) for the purpose of laying a drain pipe in a trench cut to a depth of 60cm. The bedrock was seamed, and so could be lifted in 'chunks' by the teeth of the back-hoe. The ca 60cm west face section of bedrock throughout the length of the track revealed uniform material.

Interpretation. Observations made during this commercial excavation suggest that the track on the north side of the river is indeed, as argued above (Selkirk, 1986, 5), a "mirror image" of the south bank track. They both consist of topsoil covering sandstone bedrock, and both are devoid of cut stone.

However, rather than a Roman road, both tracks conform to an ill-prepared, poorly-maintained Medieval 'hollow-way'. Branching west towards the Priory from the Devil's Causeway, which most likely had

---

[1] This work was managed by Les Morrison.

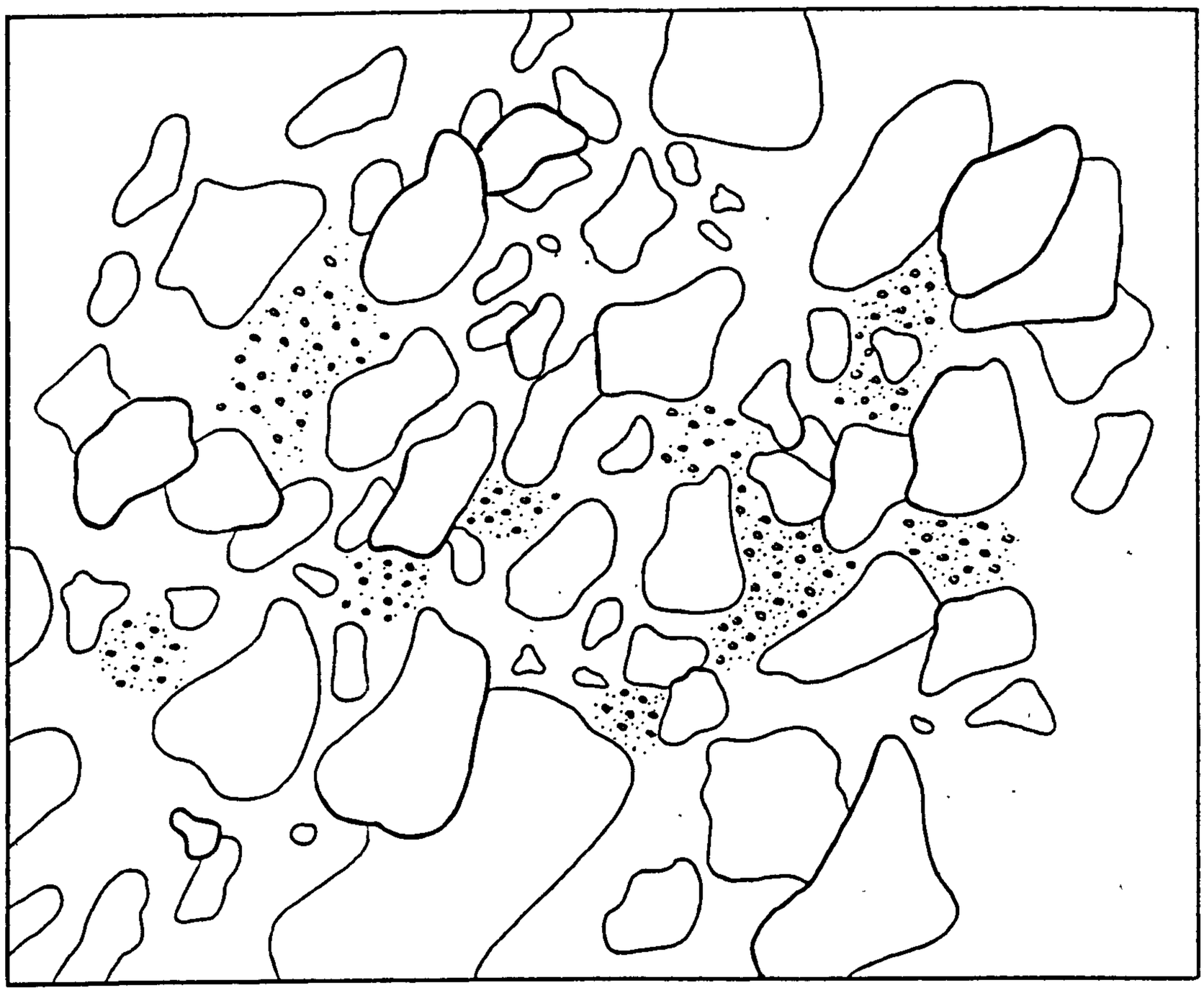
Fig 59: Brinkburn Trench 1 Plan

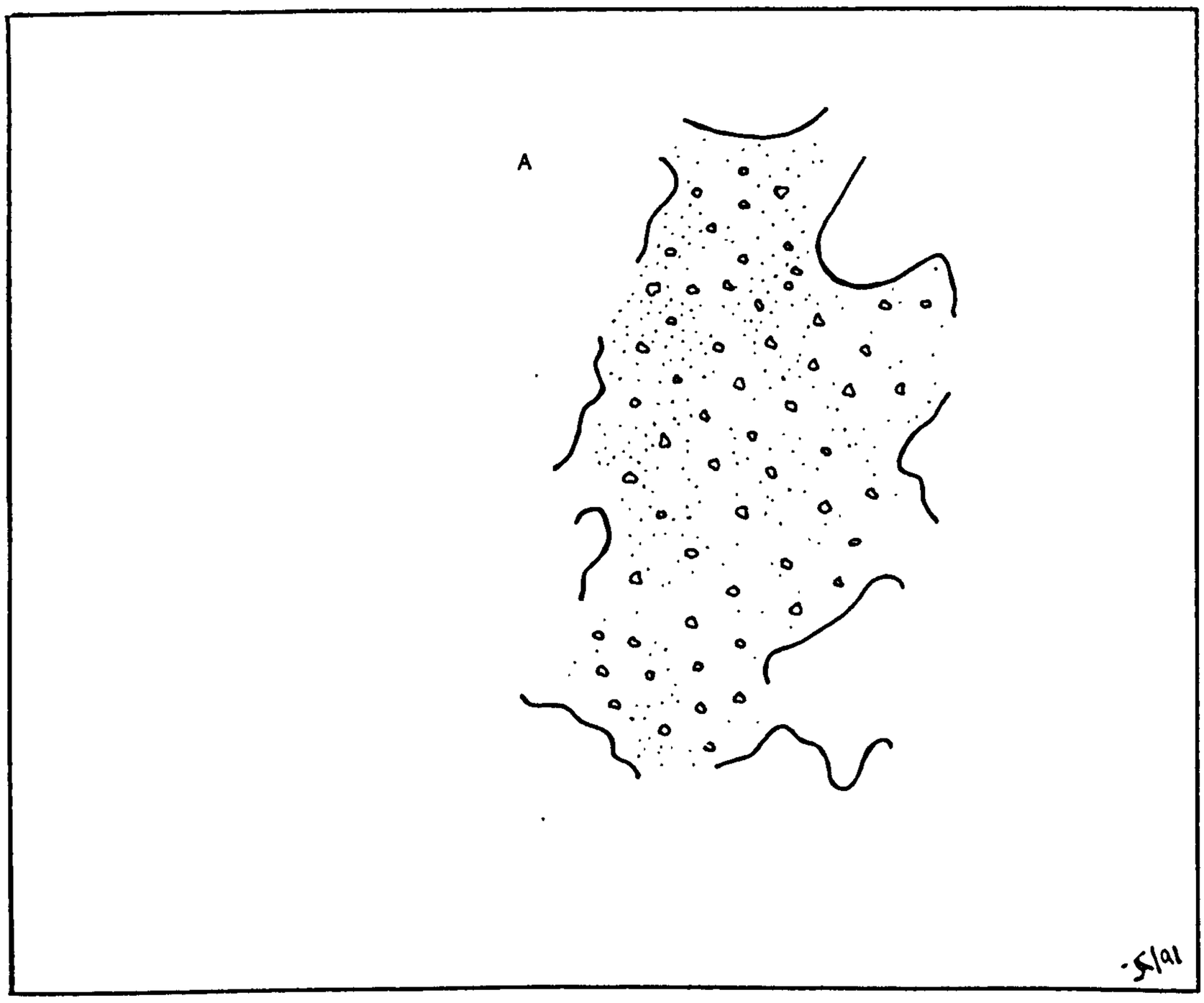
A MORTAR REMOVED FOR C14

0 1m

1:200

ELEVATION: 49m





continued in use in certain stretches from the Roman period,[1] the track descended the Coquet's south bank at a point as close to the Priory as the terrain would allow. Having crossed a bridge (discussed below) to the Coquet's north bank, the track branched west along the river to the mill-works and Priory, and north-east around the east flank of the promontory. The track, then, conforms well with the Priory context. The gradient of the north bank track, much less than that of the track ascending the north bank behind the Priory to the west, may have rendered it a preferable 'by-pass' route around the Priory after traffic had crossed the bridge.

Roman bridge

Excavation of Trench 1: the bridge pier. An excavation was made on March 1, 1989, of the bridge pier (see figures 56, 59).[2] In addition to the high winter spate of the Coquet at the time of excavation, locating this structure was made difficult by the fact that the pier was not found where it had been described (Selkirk, 1986). Rather than "in the middle of the river", it was found closer to the north bank, and 4m east and downriver from the line between the two abutments described above (ibid.; see figure 55).

---

[1] For the continued use of Roman roads in the Medieval period, see Margary, 1948, 20.

[2] The excavation was carried out with the assistance of Dave Cowley and the permission of the landlord, Mr Hugh Fenwick.

Once located, twine was wound around stakes driven into the river bed to form a rectangle measuring 2m north-south by 2.5m east-west containing the pier stones lying 50cm under the water's surface. After clearing the stones of sand and gravel, large areas of mortar were identified. As the greatest concentration was in the E aspect, large stones which had been set into the mortar were removed (see figure 59: A). Indentations of these stones were evident in the mortar surface, indicating that the stones were placed before the mortar had hardened, and that the mortar set after it had been placed in the river.

Mortar Analysis. About 15kg of mortar were excavated for examination. After allowing the sample to dry, the sample was pulverized into a coarse powder. The mortar consisted of limestone (melted), sand (aggregate), gravel, clay, and a total of 4.8g charcoal. The charcoal sample was radio-carbon dated to 3780 BP +/- 100 (Beta-37625), or BC 1830 +/-100. As this date is far too early for the production of mortar, the sample must have been contaminated. The inclusion of charcoal in this sample suggests wood was used to maintain a high temperature of the mortar matrix, most likely in order to prolong the period before the mortar hardened. As discussed below, a certain amount of coal was used probably for the same purpose, and its accidental inclusion in the sample may account for the distortion of the radio-carbon date.

Having failed to date the mortar by the radio-carbon method, another sample of mortar was then excavated from the river bed, and together with river sand taken from four areas around the pier and local sandstone and

limestone, was submitted to Graham Morgan, a mortar specialist at the Department of Archaeological Sciences, University of Leicester, in December, 1990. His conclusions are as follows.

The mortar sample consisted of 20 per cent burnt lime and 80 per cent aggregate, within which was recovered 49 per cent gravel, 44 per cent sand, and 7 per cent silt. The high percentage of gravel suggests more of a 'concrete' than mortar sample. Throughout the gravel were found felspars (felspathic porphyry and andesite), quartz, quartzite, sandstones (white fine sandstone and coarse white micaceous sandstone), micaceous schist and flint. The mortar also contained fragments of coal, red fired clay (possibly brick), and a fragment of fossiliferous grey limestone. Analysis of this limestone gave a calcite value of about 94 per cent, which would have produced a good lime if burnt. After comparison with the stone samples, it seems that all of the geological materials in the matrix are found in the vicinity of the bridge pier.

The sand in the mortar comprised mainly quartz with felspar fragments. As the particle type and size distribution of the river sand samples are very similar to the mortar sand, it is without much doubt that local river sand was used to make the mortar aggregate. Intrusions into the sand included small amounts of red burnt clay, slag or black glass and white glass. In total, it seems most probable that local sandstone was used as gravel, the local river sand as aggregate, and local limestone as bonding.

Interpretation of Excavation Results. As the greater proportion of mortar was found only under and between the stones in the E quadrant, the pier may have been constructed in the following way. After mortar was poured into a circle of stones placed on the river bed, stones were laid into the mortar, and the whole was allowed to harden. The pier was later constructed upon this base. The stones lying outside the mortar area may represent tumble from the bridge collapse.

It seems likely that this structure post-dates the Roman period. Indeed, its construction does not resemble other known Roman bridge piers. Unlike the first-rate construction at Corbridge and Chesters (see Bidwell and Holbrook, 1989), the stones in the Brinkburn pier are not set according to a contrived plan. In addition, not one of the stones was cut or could be considered opus quadratum, and no evidence exists for lewis holes, crowbar slots, or square dowel holes found in abundance at Chesters and Corbridge (Bidwell and Holbrook, 1989).[1]

As for the mortar, certain features suggest that it is not "typically Roman ... with normal ingredients" (Selkirk, 1986, 6). Although the analysis recovered some burnt tile, the overall quantity was very small, and in fact was identified with the aid of a microscope. However, it seems rather that potsherds, tile, and brick fragments comprising

---

[1] In contrast, a total of 163 stones with lewis-holes have been found at Chesters bridge (Bidwell and Holbrook, 1989, 119).

pozzolana[1] within Roman period hydraulic mortar found in Britain are large and plentiful, and easily identifiable with the naked eye (Rayment and Pettifer, 1987, 10). Therefore, the almost negligible quantities of pozzolana in the form of brick, tile or pottery argues against this mortar dating from the Roman period.

Finally, the character of the left bank abutment supports the argument that this bridge was not of Roman construction. The abutment, comprising two rows of stones, one on top of the other, with the top layer recessed into the river bank, contained stones uncut on the bank-side of the abutment. Further, the core of the abutment was filled with clay and rubble. Uncut stones and this type of fill is unparallelled at Chesters or Corbridge (see Bidwell and Holbrook, 1989). Also, rather than having "the normal Roman feathered tool marks and lead ... between the stones" (Selkirk, 1986, 6), the stones have been cut with short diagonal lines in chevrons, not in any way resembling Roman feathers (discussed above, 3.1.2; see plate 39). The style of tooling in the Brinkburn abutment could represent any period, and is not special to the Romano-British period (pers comm P T Bidwell). Finally, no lead was found between any of the eight stones examined.

---

[1] Pozzolana in the form of incompletely crushed bricks, tile and pottery was used in the Roman period whenever natural pozzolana could not be found, such as in Britain. Natural pozzolana consisted of fine dust (silicous and aluminious materials) expelled from active volcanoes and found in abundance near Pozzuoli (near Mount Vesuvius, and giving the name pozzolana), and the Greek Island of Thera. Whatever the ingredients, pozzolana, when combined with lime, caused mortar to harden without exposure to air (Jull and Lees, 1990, 5).

Fort platform

The 'fort platform' west of the Priory seems otherwise (see figure 54: E). First, no evidence of Roman period pottery or artefacts, or structures such as ramparts suggest an occupation. Second, it seems that the rectangular 'corners' were formed rather by river action (see MacLauchlan's plan, 1864; figure 60). In the south aspect of the 'S'-bend directly across the river from the Priory, a face of limestone and sandstone ca 20m in height has stopped the southern meander of the river. During times of flood, the banks of this 'chute' would limit the amount of water passing through, so that water would 'pond-up' over the flood-plain upriver and below the 'fort platform'. The recession of this water would scour the inside of the bank (Morisawa, 1985, 122-3), resulting in the trimming of the 'fort platform'.

By-pass canal below fort

The 'canal' below the fort used for collecting fish in the Medieval period (Hodgson, J C, 1904, 487) was formed by natural forces. Indeed, the channel shows no evidence of artificiality and is unlike other fish-ponds (OS Antiquity Card: NZ19 NW18 1957). It is rather a 20m wide flood plain back-channel, formed by the same processes which acted upon the back-channel at Bywell (discussed above, 4.2.2): that is, it was cut during successive periods of flood recession across the flood-plain.

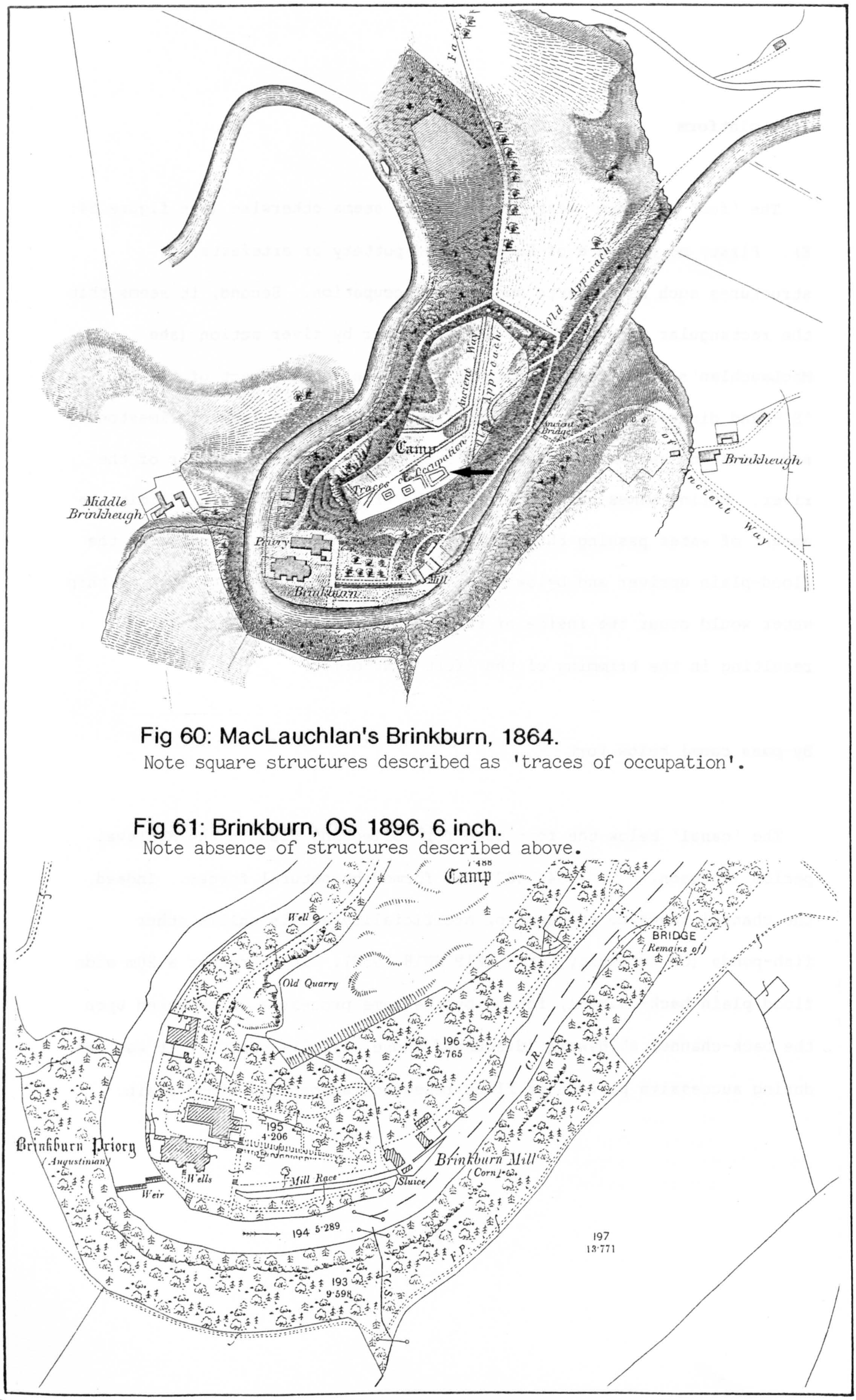


Fig 60: MacLauchlan's Brinkburn, 1864.
Note square structures described as 'traces of occupation'.

Fig 61: Brinkburn, OS 1896, 6 inch.
Note absence of structures described above.

By-pass canal below the Priory

The stones in the mill-race comprising the 'by-pass canal' are almost certainly Medieval, perhaps dating to the first mill on the site, constructed at the same time as the Priory (Page, 1892, 13).

> "...in the masonry of the cottages now erected where the mill stood is a quantity of re-used Medieval stonework, whilst the abutment wall seems to be entirely old."
>
> J C Hodgson, 1904, 487

The stone-lining in the retaining walls and part of the walls abutting the river south-east of the mill also appear Medieval (OS antiquity card NZ 19 NW 1). Nowhere does evidence exist for lewis-holes, feathers, cross, or diamond-broaching or any other characteristic common to the Roman period. The mill-race is indeed large, perhaps so because it serviced a large mill, rather than providing a by-pass canal or harbour for Roman barges.

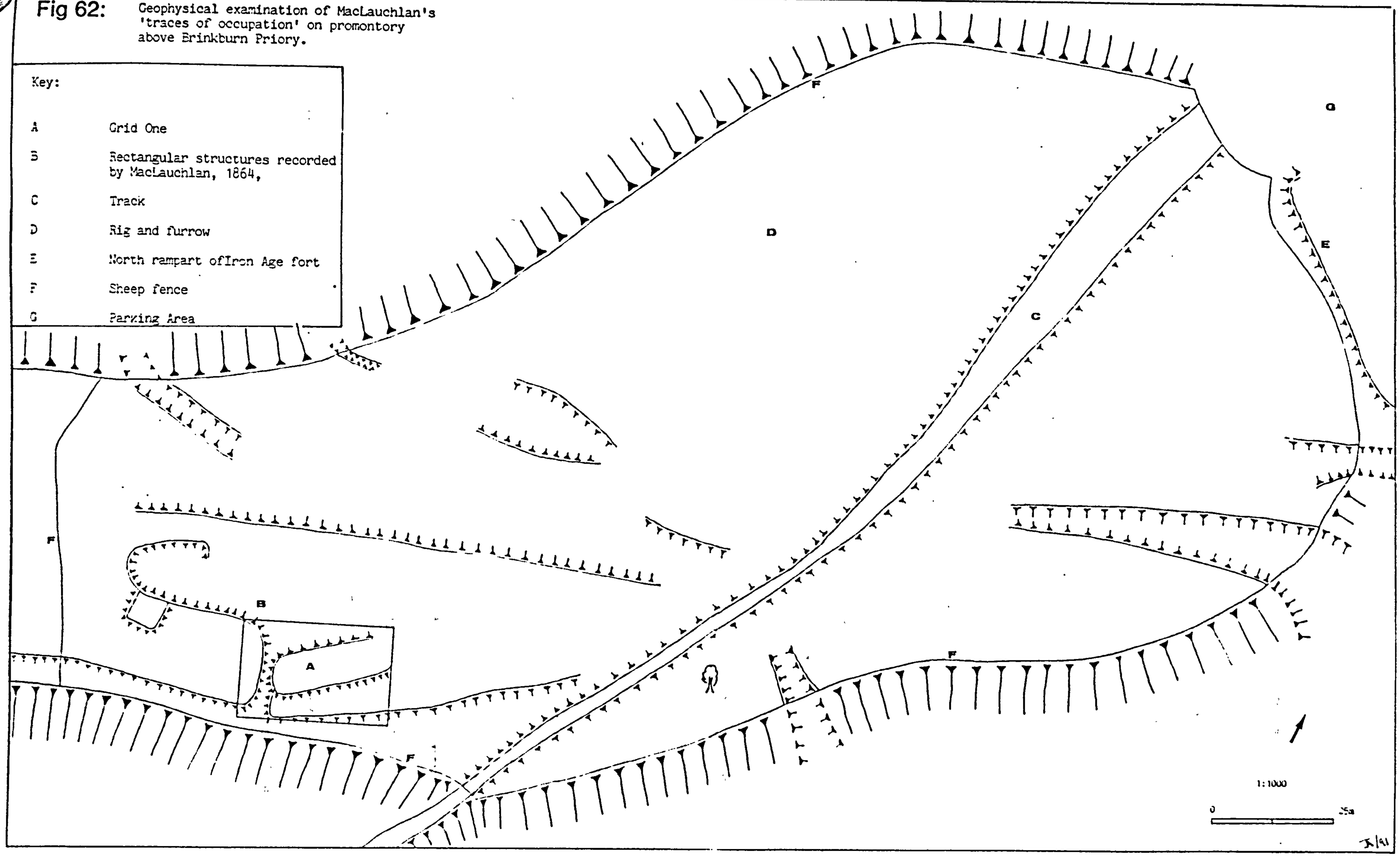
Dam

Although the second edition OS map (1896) depicts a weir below the Priory (see figure 61), nothing remains of this structure today. However, its position downriver from the entrance to the mill-race suggests that this dam was built to form a reservoir for the Medieval mill-works. While the possibility exists that a Medieval dam was constructed over a Roman period dam, given the proliferation of Medieval and complete lack of Roman period structures, it is reasonable to assume

Fig 62: Geophysical examination of MacLauchlan's 'traces of occupation' on promontory above Brinkburn Priory.

Key:

A	Grid One
B	Rectangular structures recorded by MacLauchlan, 1864,
C	Track
D	Rig and furrow
E	North rampart ofIron Age fort
F	Sheep fence
G	Parking Area



that this dam was constructed in conjunction with the 12th century Priory and mill-works.

Roman period occupation on promontory above Priory

As for a Roman period occupation near the Iron Age promontory fort, it is more likely that these buildings noted by MacLauchlan (1864; see figure 60) belong to a Medieval rather than Roman period context. First, no artefactual evidence such as pottery or coins of the Roman period has been recovered on the promontory, or anywhere else in the Brinkburn Priory environs (OS antiquity card NZ19 NW18). Second, not only the Priory, but the mill-race, bridge, and tracks have so far been found to belong to a Medieval context. However, interpretation of these structures is made difficult by the fact that MacLauchlan's initial sketching of these structures in 1864 has not been subsequently included on surveys of this area. In order to gain more insight into the character of these rectangular structures, a geo-physical examination was made in March, 1991 (for a full discussion, see Anderson, Rushworth, and Willis, forthcoming).

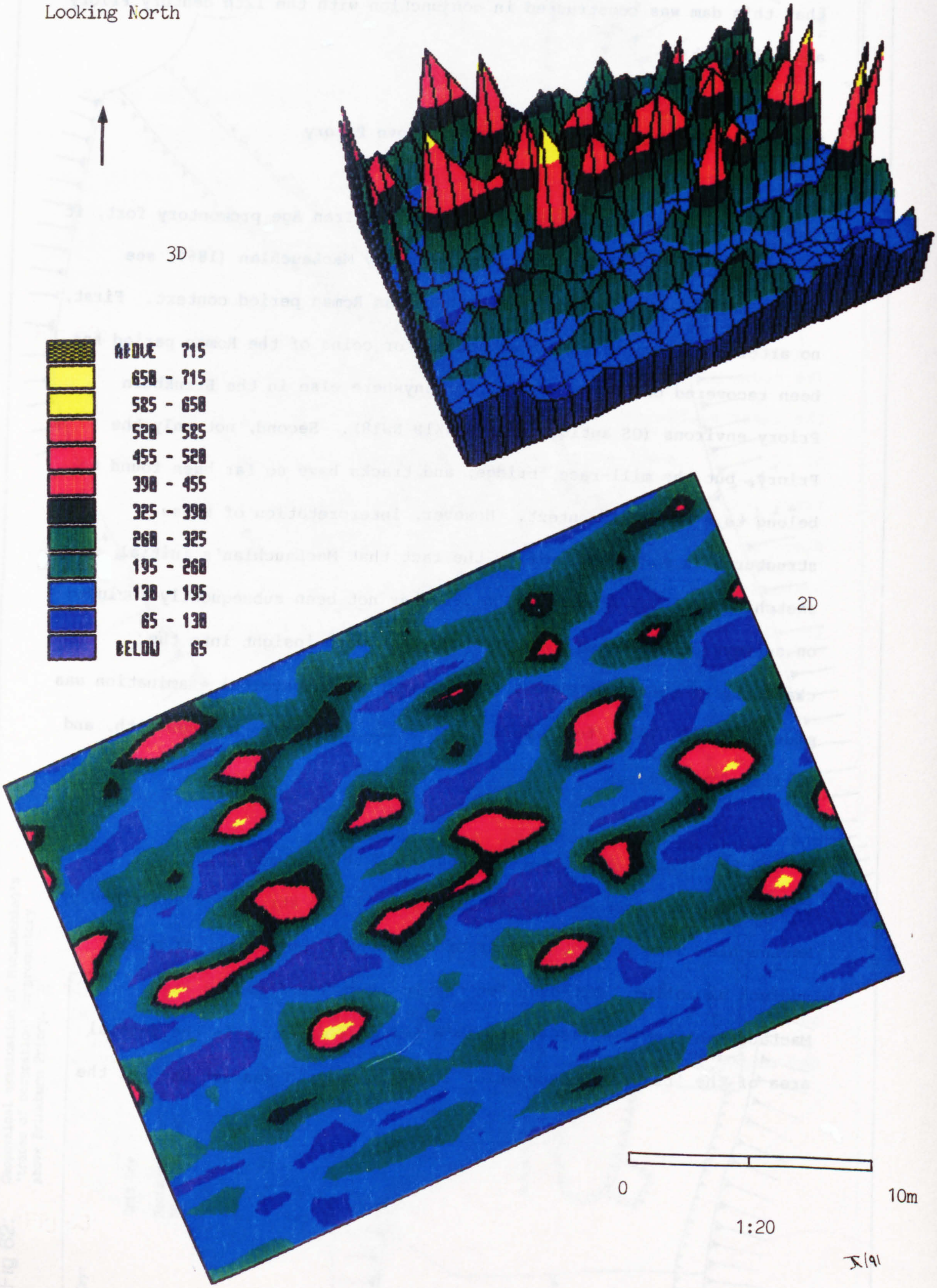
Geo-Physical Examination. It was hoped that by geo-physical examination it might be determined whether those structures described by MacLauchlan were in fact remains of rectangular buildings, or merely surface anomolies. Although not nearly as well-defined as in MacLauchlan's sketch (1864), surface features do exist in the general area of the 'traces of occupation'. A 30x20m grid was set up over the

Fig 63:

Brinkburn Resistivity: Grid One

3.91

Looking North



most pronounced of these structures, and part of another (see figure 62). The two dimensional 1:20 plan of the resistivity results shows three rows of stones (see figure 63). When this plan is compared with the surface undulations shown on figure 64, it appears that two lines of stones lie along the outside of the rectangle, with one line bisecting it.

The gradiometry results are far less illustrative, showing merely areas of greater or lesser magnetic pull across the grid in no set pattern (see figure 64).[1] However, an occupied site would indeed show many differences in magnetic forces, and a lack of variation across this grid would have been conspicuous.

Generally, the results of the resistivity seem to represent the stone foundations of a rectangular structure: the two outer lines of stone follow the mounds of earth seen on the surface, and most likely represent the stone foundations for walls. The inner row may represent a line of stone which fell from one of the two walls, maintaining its 'course' upon the ground. Such a structure conforms well with a Medieval farming context. Indeed, rig and furrow overlying the Iron Age fort attests to the use of these fields for cultivation in the Medieval period.

---

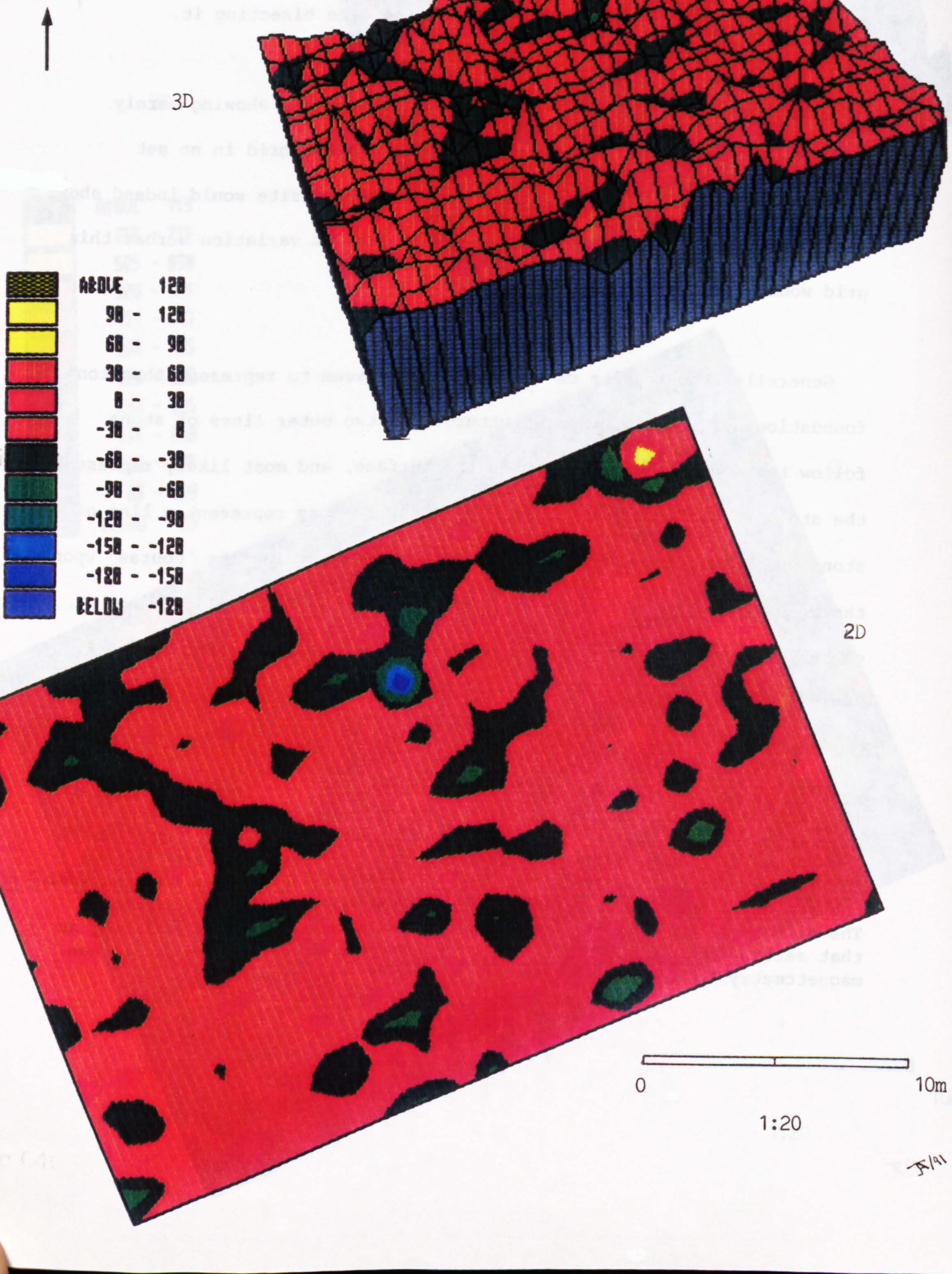
[1] The gradiometry system used in this thesis works on the same principle as that described for magnetometry above (5.1.2), except that two rather than one impulses are projected vertically into the earth. The first is projected from ground level to a 3m depth below the surface, the second from 1m above ground level to a 2m depth below the surface. The difference between the two readings represents an average reading in that section of the sub-surface, and is therefore less susceptible than magnetometry to anomalies such as bottle caps or barbed wire.

Fig 64:

Brinkburn Gradiometry: Grid One

3.91

Looking North



Alternatively, its long, thin construction, as well as its position upon a large area suitable for grazing and adjacent to the track running over the Iron Age fort across the promontory and south down the hill to service the Priory, recommends this structure as a stable.

5.2.3 Conclusion

The site around Brinkburn Priory does not have the many Roman structures described in The Piercebridge Formula and later publications. The track running down the south bank of the Coquet towards the Priory from the Devil's Causeway, as well as the track running up the north bank to the east of the promontory have been shown by excavation to be contrary to what is expected of a Roman road. Furthermore, the construction and craftsmanship of the bridge pier and abutment is uncommon to known Roman bridges in the North-east, while the mortar does not conform with other Romano-British matrixes. Altogether, the tracks and bridge most likely belong to the context of the nearby Medieval mill-works and Priory buildings. The mound of earth argued to be a 'fort platform' on the right bank west of the Priory was formed by flood-waters trimming the inside curve of the river, while the 'canal' below the 'platform' is more likely a flood-plain back-channel, scoured by the recession of the same floods which trimmed the 'platform'. No evidence exists for Roman period construction of the mill-race, and nothing suggests a Roman period occupation on the promontory above the Priory.

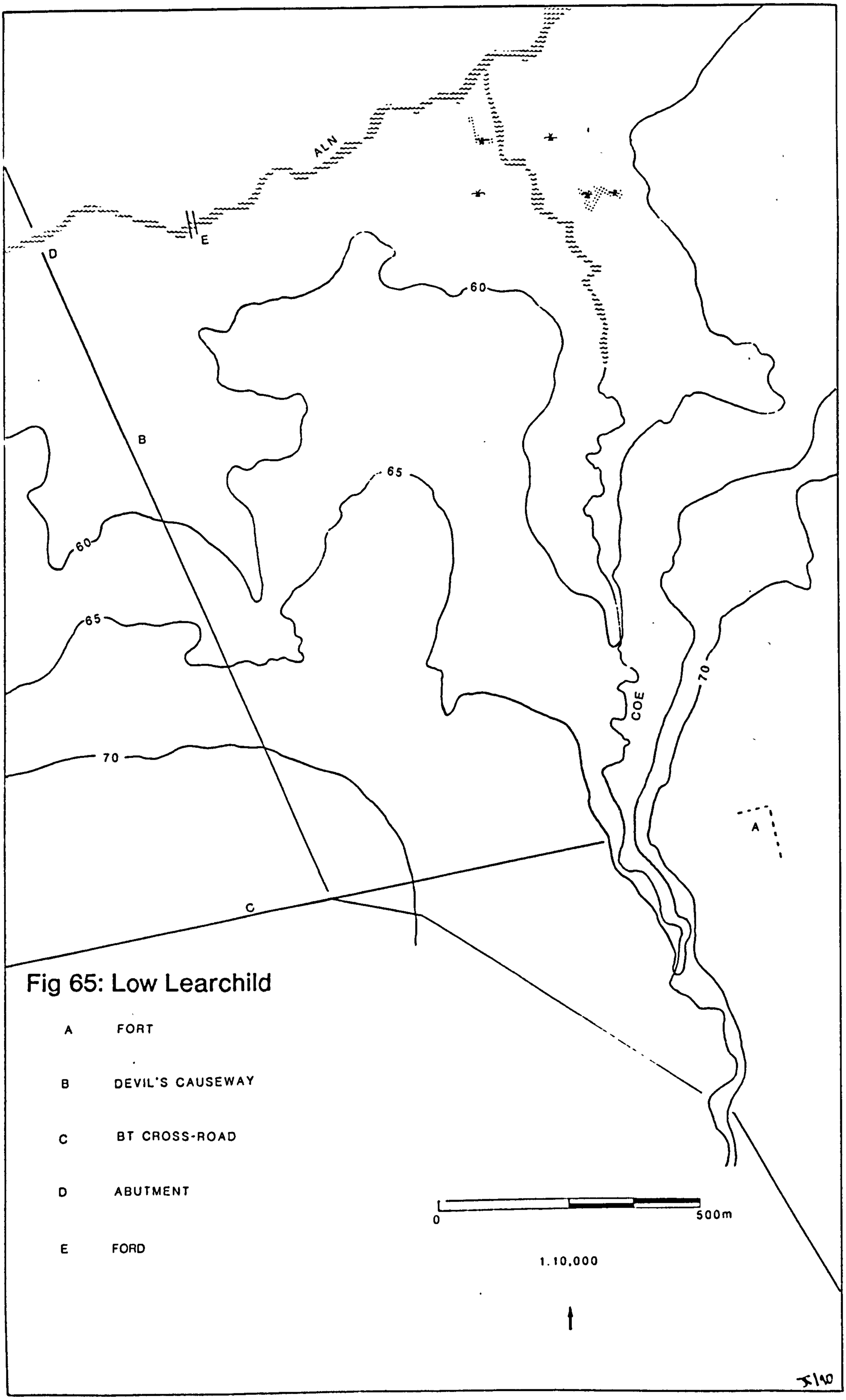


Fig 65: Low Learchild

A FORT

B DEVIL'S CAUSEWAY

C BT CROSS-ROAD

D ABUTMENT

E FORD

0 500m

1.10,000

X140

5.3 LOW LEARCHILD

The Roman fort at Low Learchild lies on a fairly flat field, with a hill to the east, and a good view northwards down Coe Burn to the River Aln, which falls 34km to the sea. The fort also lies on the east flank of the Devil's Causeway which, branching from Dere Street near Bewclay Farm just north of Portgate on Hadrian's Wall, crosses the Aln 12km downriver from Alnham, and continues to Berwick-upon-Tweed, covering 98km in total. Just south of the fort, the Bremenium-Thrunton cross road runs east-west from the Devil's Causeway 36km to High Rochester fort on Dere Street. As discussed in Appendix J-2.2, pottery evidence and excavation (Taylor, M V, 1947; Richmond in Taylor, M V 1957, 206; pers comm C M Daniels) has dated the two forts on the site to the Flavian period. The dimensions of the later fort are unusually large, and it is argued that the fort may have held a cavalry regiment (E B Birley, 1961, 245). According to the Piercebridge formula (Selkirk, 1983, 101), Low Learchild fort would have been supplied via ships sailing into Alnmouth and barges navigating the Aln either to the Coe Burn and then to the fort, or to the Bridge of Aln on the Devil's Causeway and overland to the fort.

5.3.1 Evidence Supporting the Piercebridge formula

The occupational time frame and geographical setting of Low Learchild fort strongly recommend it as a Piercebridge formula site (see figure 65). The first Flavian period fort would have been constructed at the beginning of the Roman presence in this area, and well before supplies

Plate: **43** Aln valley from Jenny's Lantern, NU 1115 1215; west facing east; Aln flowing north. The foreground, cultivated in the Romano-British period, is now under pasture.

Aln valley from Jenny's Lantern (100m north of plate above); west facing east. Note pasture in foreground, cultivation on valley floor.

could have been gained in any considerable quantity on a local level. Therefore, the garrison at Low Learchild would have been dependent on supplies transported from long distances away (discussed below, 6.2.1; Appendix J).

However, Low Learchild is further from a supply base than any site in the North-east. Along the Devil's Causeway, Corbridge lies 51km to the south, and Berwick-upon-Tweed (if in fact it was a supply base: discussed below, 6.1.3) 52.5km to the north. If provisioned via High Rochester, which also must have been provisioned by Corbridge, the distance would have been 36.8km. Conversely, if supplied according to the Piercebridge formula, barges would have navigated only 36.6km from Alnmouth to the fort via the Aln and Coe Burn.

5.3.2 Evidence Refuting the Piercebridge formula

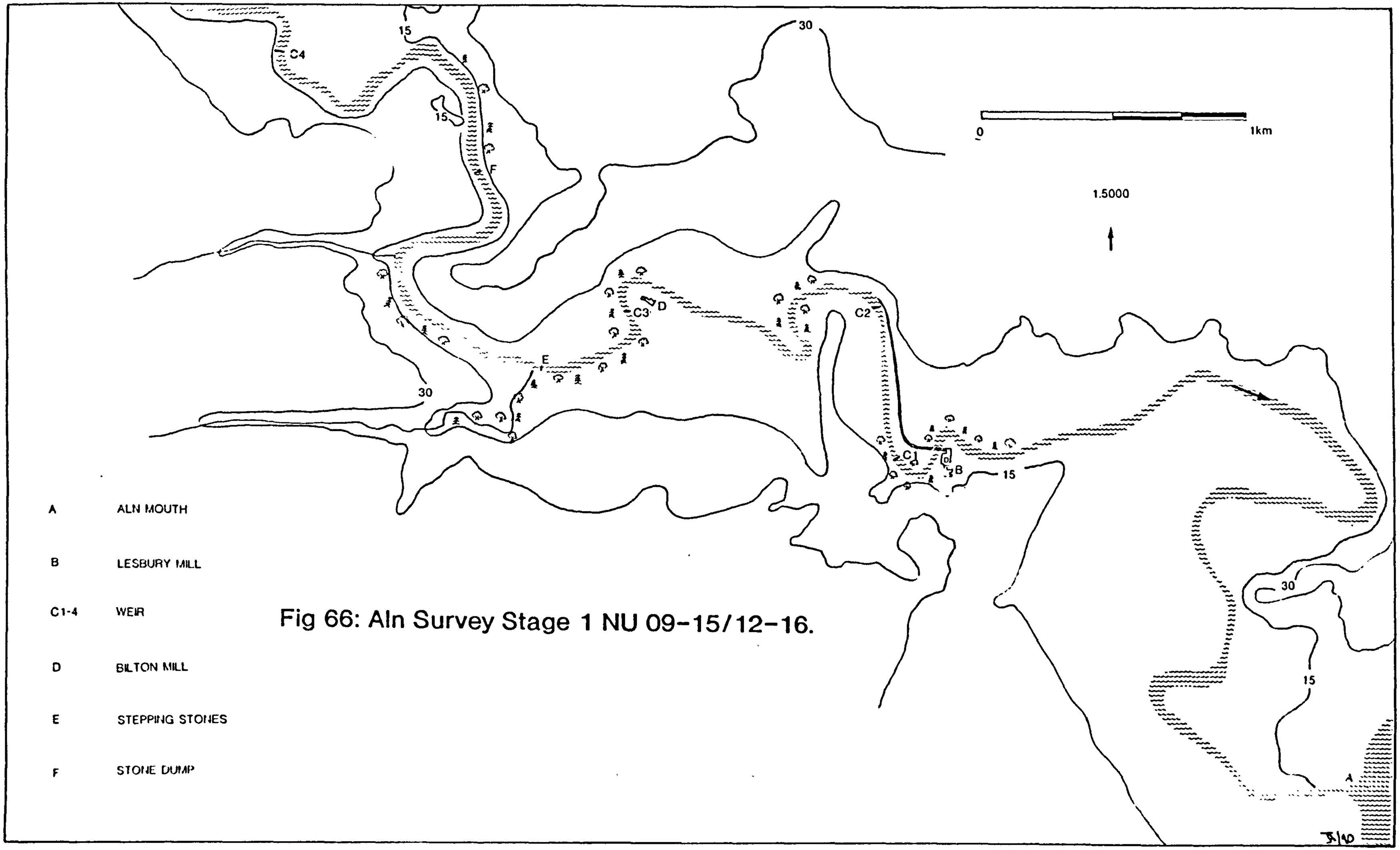
Evidence for the Piercebridge formula was sought in two separate surveys in March, 1988. The first survey covered 34km along the River Aln, stretching from Alnmouth to the confluence of the Aln and Coe Burn. The second survey comprised a 2.6km stretch of the Coe Burn from its confluence at the Aln to the fort. The aim of both surveys was to identify, if possible, Roman period hydro-engineering works, or even Roman period masonry. This involved examining the stones of extant structures within or along the banks of the Aln and Coe Burn for Roman period construction techniques, such as lewis-holes, cramp-holes, iron cramps, crowbar slots, feathers, cross-broaching, finely-cut edges, or

Plate: **44** River Aln near mouth, west facing east, Alnmouth bridge in background, far right. The pole delineates tidal mark. To left are series of ridges formed by alluvial deposition during periods of higher river spate and sediment concentration. Today, due to less cultivation in the catchment, and therefore lower sediment concentration, the Aln is fast, narrow, and incising.

opera quadrata. Using the equation described above (2.1.1), it is possible to estimate the number and frequency of Piercebridge formula dams as well as associated locks and canals which would have contained such Roman period masonry. In the first survey, as the modern tidal mark is at 4m OD, and the OD at the confluence of Aln and Coe Burn is 55m, 17 Piercebridge formula dams at a rate of .58 dams/km would have been constructed between the tidal mark and the confluence of the Coe Burn 29km up the Aln. In the second survey, as the elevation at the confluence of Coe Burn and Aln is 55m OD, while at the fort the OD is 75m, 7 Piercebridge formula dams at a rate of 2.7 dams/km would have been constructed between the confluence at the Aln and the fort 2.6km up the Coe Burn.

Survey I: The River Aln

By the time the Aln has reached its confluence with the Coe Burn, it has dropped from its main catchment area in the Cheviot Hills and crossed a bold ridge of Fell sandstone running south and south-west. From its confluence with the Coe Burn, the Aln follows a relatively gentle gradient of .62m/km, and crosses two broken ridges, the first west of Alnwick, and the second at Shilbottle Crag before discharging into the sea. As discussed above (2.1.2), the rivers of the North-east would have been charged with sediment in the Roman period due to high rates of cultivation, and the Aln is no exception. Pre-Roman cord-rig cultivation near the headwaters (see figure 87) and Roman period fields and



A ALN MOUTH

B LESBURY MILL

C1-4 WEIR

D BILTON MILL

E STEPPING STONES

F STONE DUMP

Fig 66: Aln Survey Stage 1 NU 09-15/12-16.

settlements have been found along the banks of the Aln.[1] These settlements have been recovered because they occupy high knolls which have not been cultivated since the Roman period. As discussed in Appendix D-4, the existence of these sites suggests strongly that the more arable lowland area also was cultivated, and further, cultivation along the Aln in the Roman period would have been more extensive than at any period since. High sediment concentrations in the Aln would have rendered it wide, slow, and meandering during the Roman period. This differs greatly from today: the catchment is given over largely to pasture, and the ground cover density is high, so that the Aln is fast-paced, narrow, and deep, with much evidence of recent incision into the alluvia.

The survey was undertaken along both sides of the Aln[2] and divided into three stages: the first comprised the area between Alnmouth and Alnwick, the second Alnwick and Holne Park, the third Holne park to the confluence with the Coe Burn.

---

[1] Large settlements and field systems have been found along a ridge overlooking the Aln valley before it enters Holne Park. In addition to the large settlement at Jenny's Lantern NU 1115 1215 (see plate 43), there appears to be one other, or at least three smaller settlements close by (see OS antiquity cards NU11 NW18-20).
[2] Assistance was provided by H D Henley.

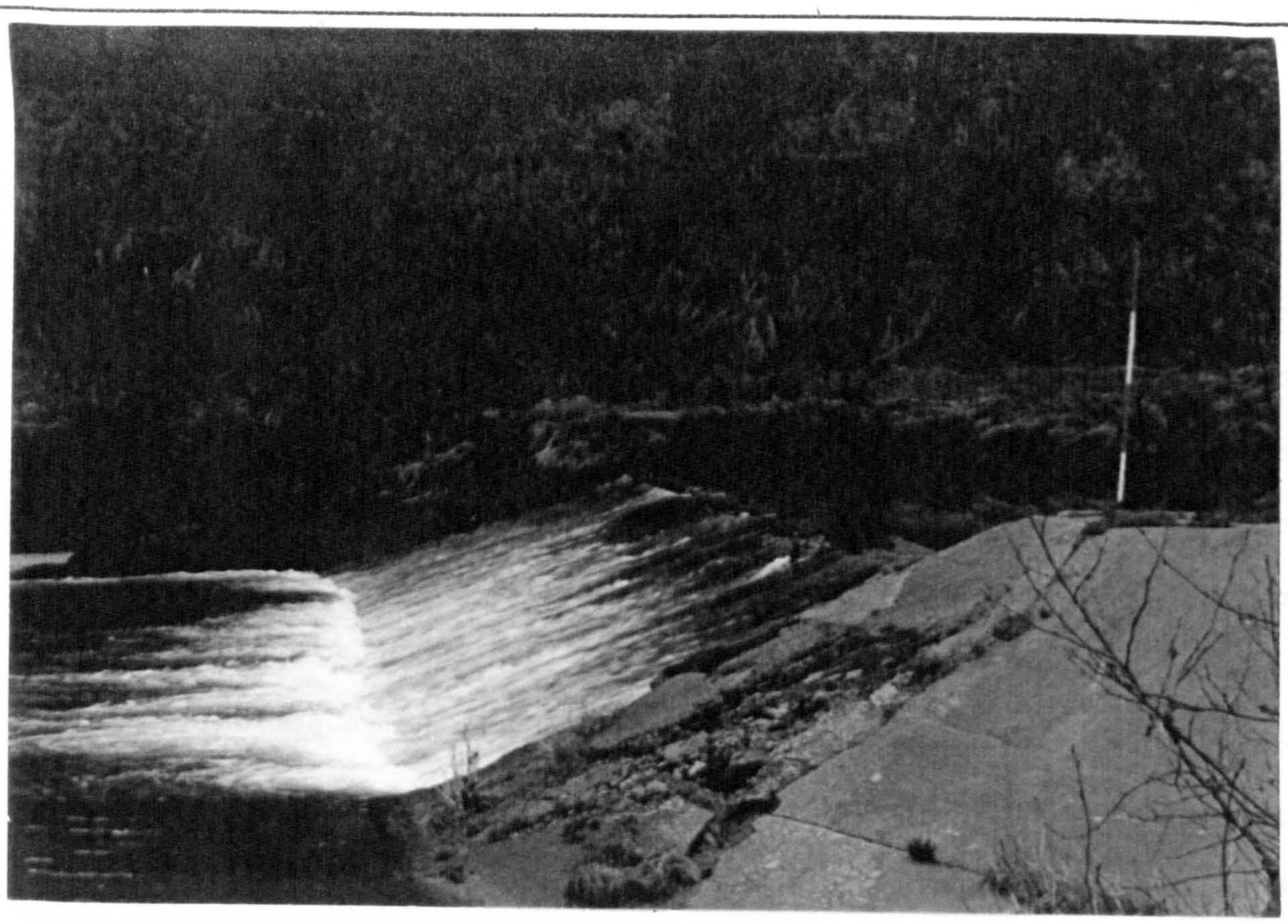


Plate: **45** Lesbury mill weir at NU 231114, north facing south.

Plate: **46** Lesbury mill race at NU 231 115 to 120, east facing west.

Stage One: Alnmouth to Alnwick. As the river mouth is relatively new, [1] the survey began just west of Alnmouth (see figure 66). The stretch of river between this point and Lesbury, still within the tidal limit, did not reveal any ancient structures. The modern river course cuts through a wide alluvial plain, consisting of ridges running parallel with the modern river course (see plate 44).

Just beyond the tidal mark of the Aln, Lesbury mill (B in figure 66) was fed by a combination of two weirs (C1 and C2 in figure 66) at NU 231 114 and NU 229 121, and a mill race, at NU 231 115 to 120.[2] Both weirs appear to have been repaired recently (see plate 45) and do not contain Roman period stone, while no stone of any description was found in the mill race (see plate 46).

Bilton Mill, about 2km upriver (NU220 120; D in figure 66)[3] is serviced by a weir at NU 119 221 (C3 in figure 66). In both structures, no Roman period stone was found.

---

[1] Before 1806, the river mouth flowed south of the Church Hill, which was united with Cheese Hill and Alnmouth by a ridge. In 1806, the river broke through this ridge and has since followed this course.
[2] Lesbury mill is first mentioned in 1352 (Bateson, 1895, 414), and recorded as producing ten pounds, thirteen shillings per year. It is again mentioned in 1443: at this point, dues were spent repairing the mill and tenants' houses at Lesbury (ibid., 415).
[3] Bilton Mill is first mentioned in 1443 (Bateson, 1895, 453) when Sir Ralph Grey of Warke left Bilton and Lesbury mills at his death in such a state of repair that they cost five pounds, seven shillings to restore.

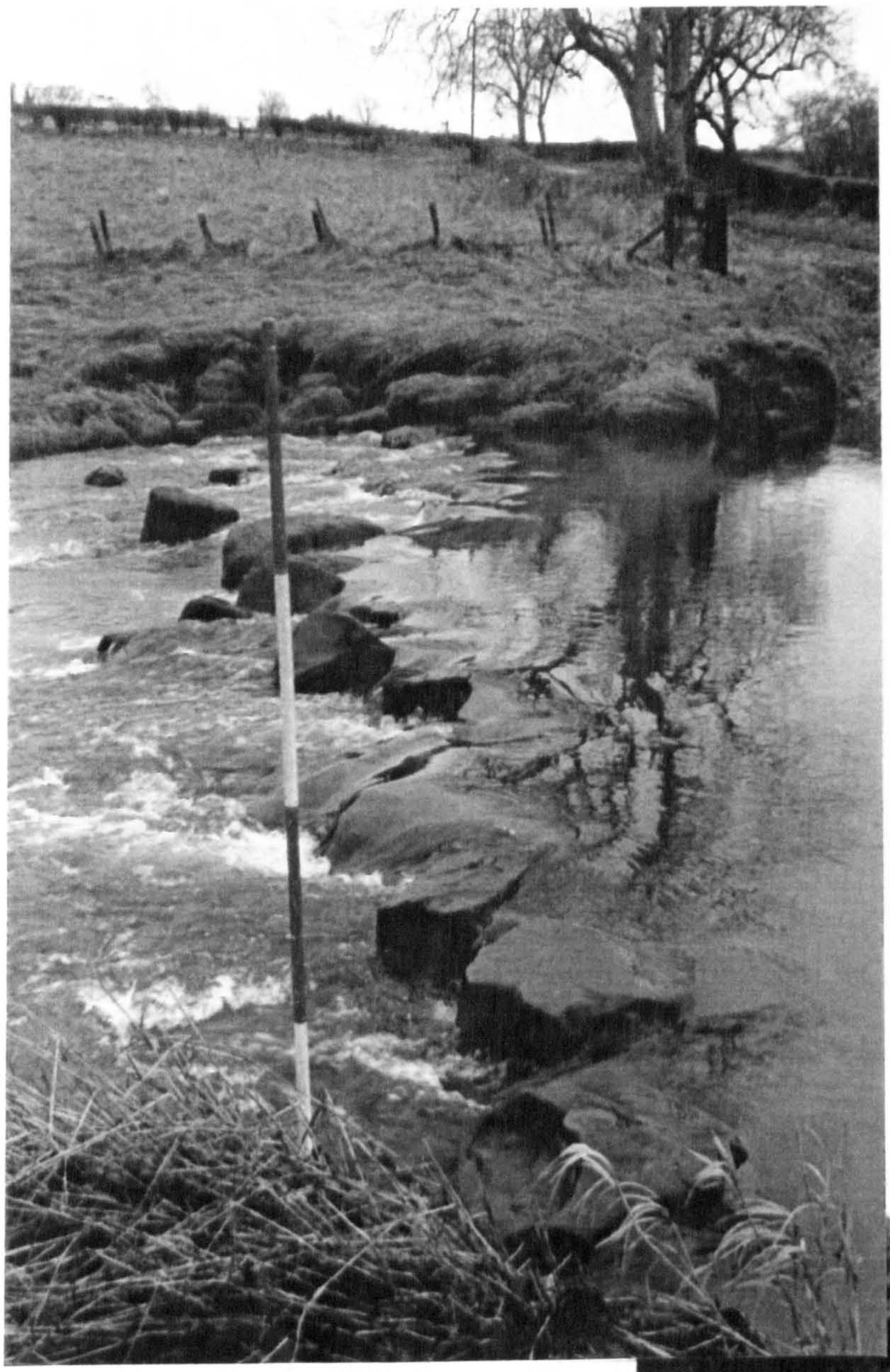


Plate: **47** Stepping stones in River Aln at NU 218 118, north facing south. Note, stones are un-cut.

Plate: **48** Boulders 150m up the river Aln from the stepping stones described above, north facing south. These boulders may have functioned once as stepping stones, or as part of a rock dump for the fields lining both sides of the river.

The next group of features encountered in stage one consisted of stones set in the river at NU 218 118 (E in figure 66 and plate 47). These stones are flat on top, and uncut on all sides. They had been placed in the river randomly, and seemed to function as stepping stones to connect fields on either side of the river. Again, these lacked Roman period workmanship.

At NU 215 125 (F in figure 66 and plate 48) stones were found in the river following a much less contrived pattern than those above. Likewise, all of the stones were uncut: it is likely that these stones were thrown into the river from the fields above and on either side of the river.

Finally, a weir survives at NU 138 208 (C4 in figure 66): no Roman period stone was found.

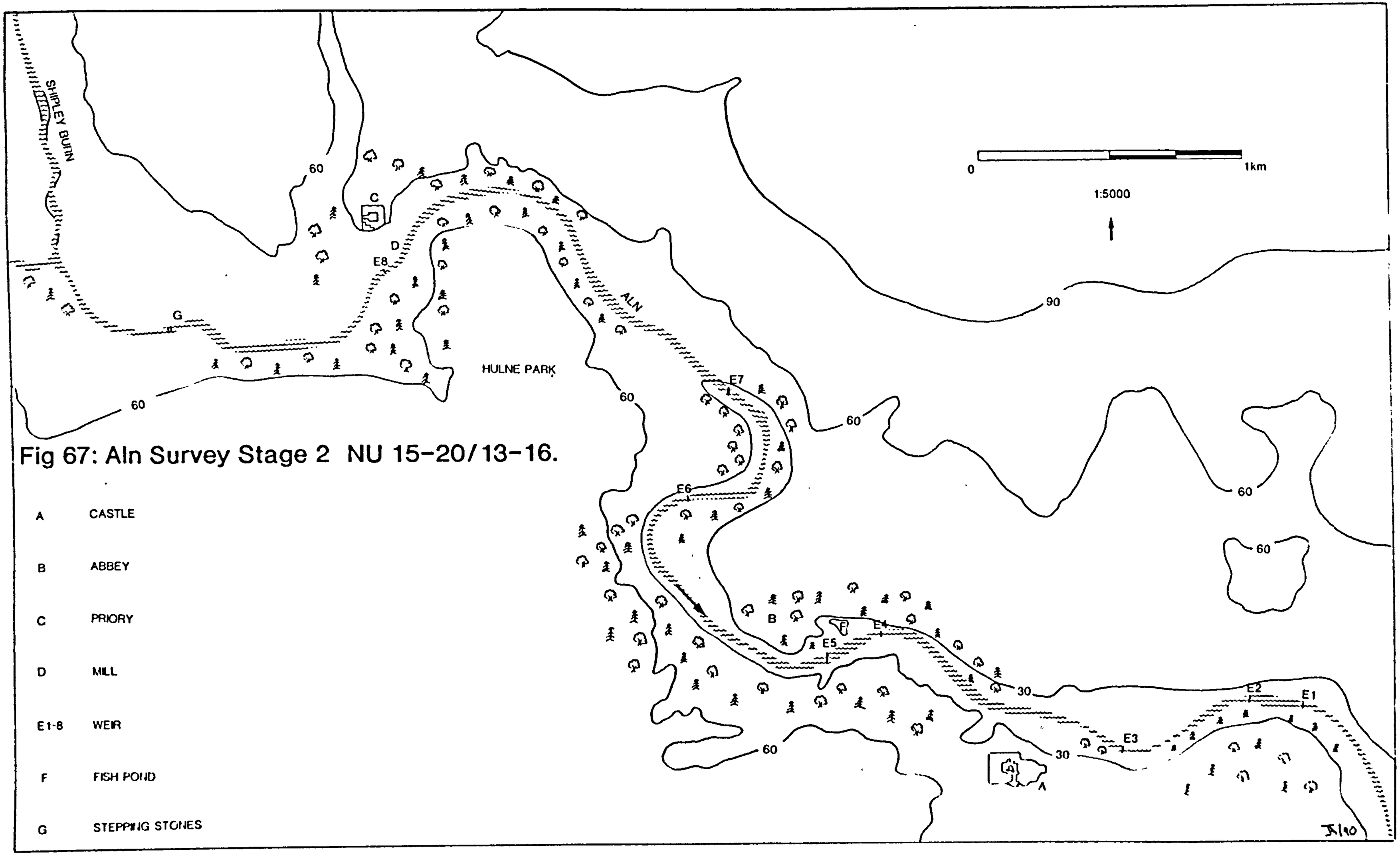


Fig 67: Aln Survey Stage 2 NU 15-20/13-16.

A	CASTLE
B	ABBEY
C	PRIORY
D	MILL
E1-8	WEIR
F	FISH POND
G	STEPPING STONES

Stage Two: Alnwick and Holne Park. This stage consists of Alnwick castle, Alnwick Abbey, Hulne Priory, one mill, eight weirs, and stepping stones.

Alnwick castle is situated on a hill overlooking the south and right bank of the Aln, at NU 188 136 (A in figure 67). Throughout the premises open to the public, no Roman period stone was found in buildings or ramparts.

Founded in 1147, Alnwick Abbey lies along the north and left bank of the Aln at NU 178 141 (B in figure 67). Little remains of the structure today, and none of the extant remains fits the description of Roman period stone.

Much more remains of Hulne Carmelite Priory, established in 1242, and located at NU 1620 1570 (C in figure 67). An afternoon was spent examining the stones across the considerably large precinct,[1] and no Roman period stone was found.

Remains of the mill below Hulne Priory (D in figure 67)[2] are not great, and the stone was not of the Roman period.

---

[1] With permission from the Warden of the Duke of Northumberland.
[2] The mill is first mentioned when John de Vescy in 1252-1289 "gave a mill, built on their own area, in which to grind their corn without multure, with a watercourse made in great water of the Aln through a foss which they had dug in the forest' (Bateson, 1895, 462).

Fig 68: Aln Survey Stage 3 NU 10-14/12-15.

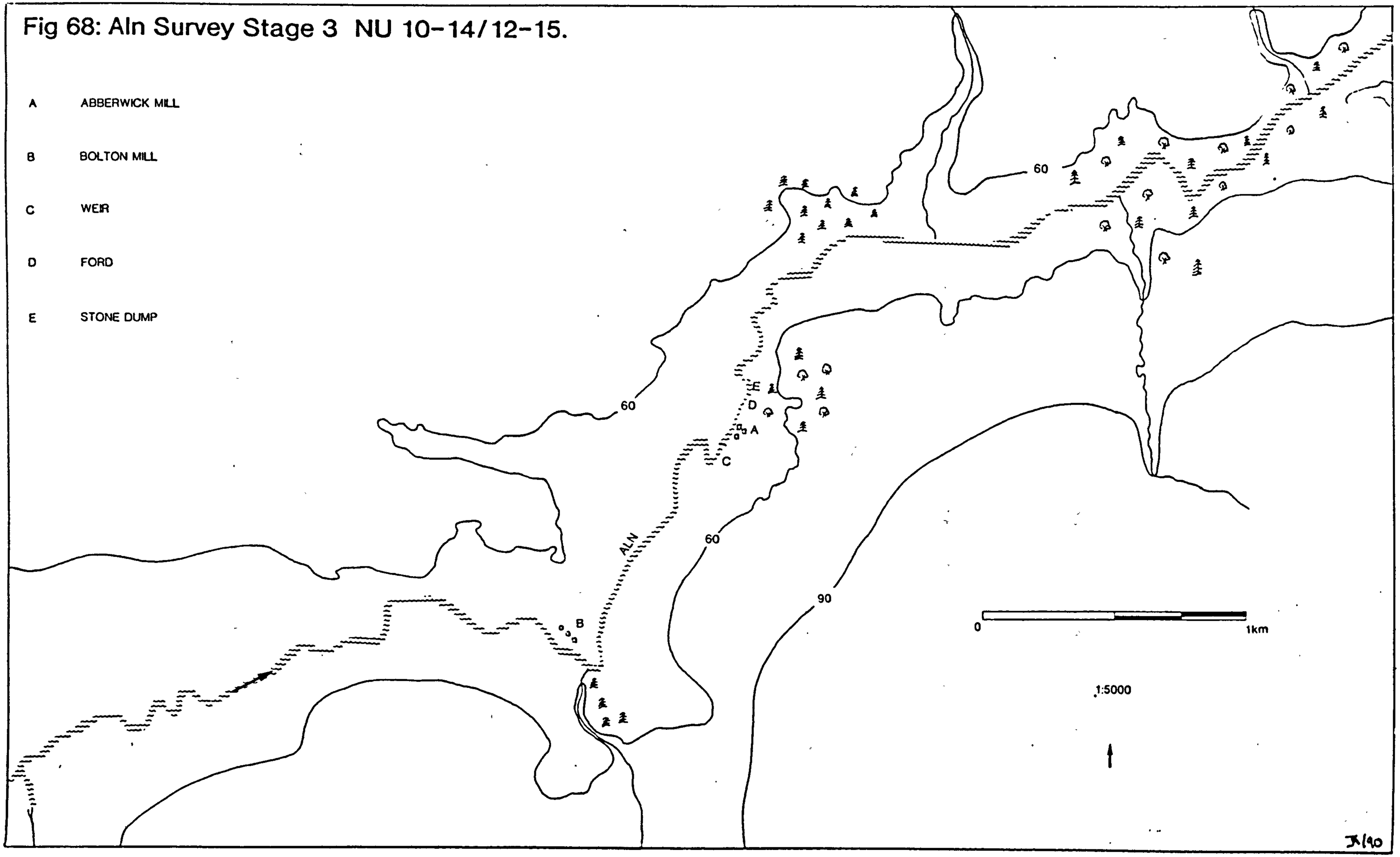
A ABBERWICK MILL

B BOLTON MILL

C WEIR

D FORD

E STONE DUMP



JK/90

As for weirs, the first three approaching Alnwick would have functioned in ponding-up the river to increase its depth below the castle, at NU 188 136 (C1, C2, and C3 in figure 67). None of these weirs revealed Roman period stone.

The next weir, at NU 182 141 (C4 in figure 67) is just downriver from a feature in the north bank described as a 'curling pond', and thought to be Medieval fish ponds (pers comm Warden of the Duke of Northumberland). If so, the weir would have provided water to fill the ponds. Whatever the function of this weir, it was not built of Roman period stone.

The next weir, at NU 180 140 (C5 in figure 67) is obviously a modern construction.

Roman period stone was absent also at the next weir called Monk's Bridge at NU 175 146 (C6 in figure 67).

The weir at NU 178 150 (C7 in figure 67) probably would have provided water for the many rig and furrow fields on either bank belonging at one point to Alnwick Abbey. No Roman period stone was found.

The final weir is below Holne Priory, at NU 163 150 (C8 in figure 67) and would have functioned in providing water for the mill discussed above. Again, no Roman period stone was found.

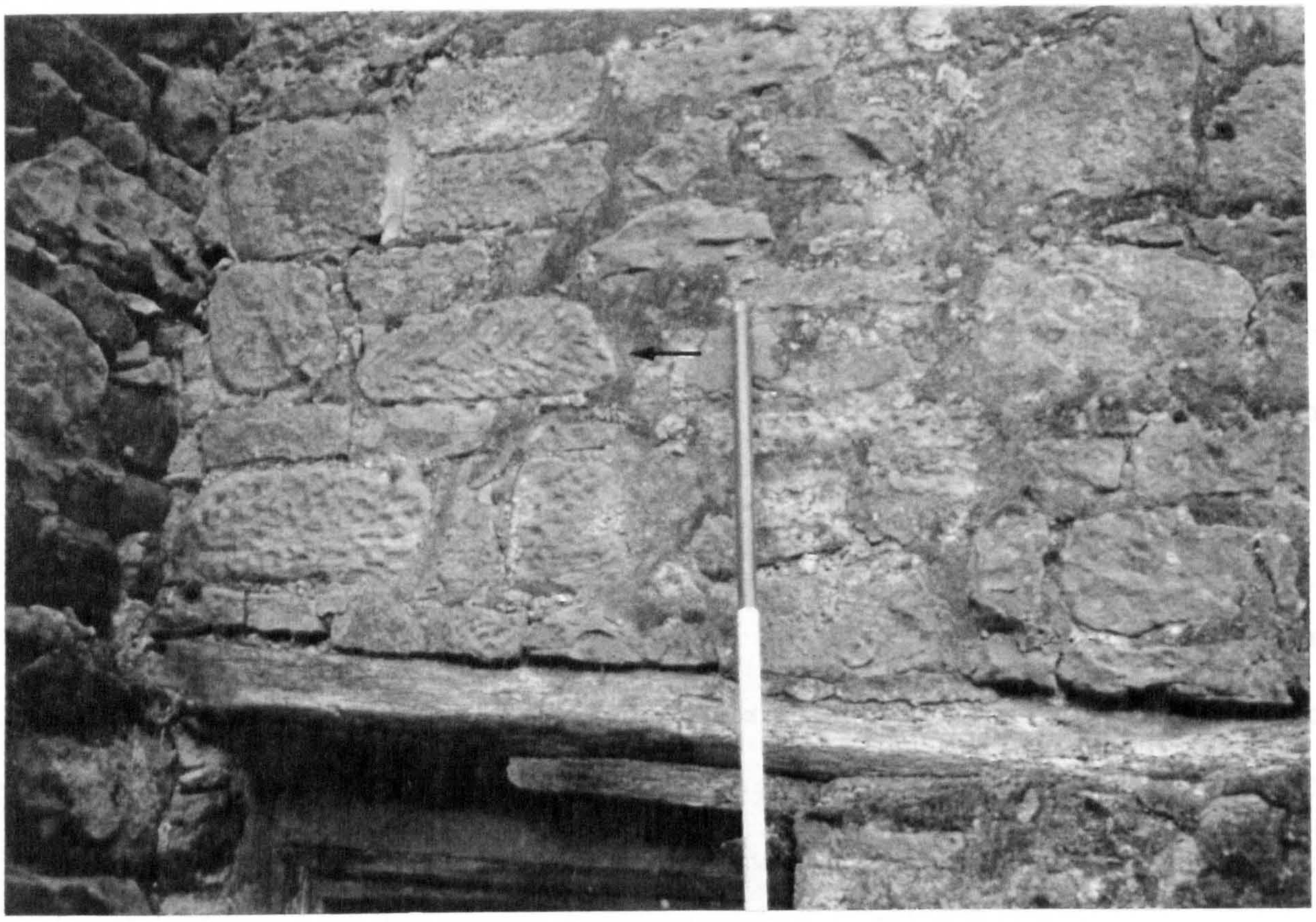
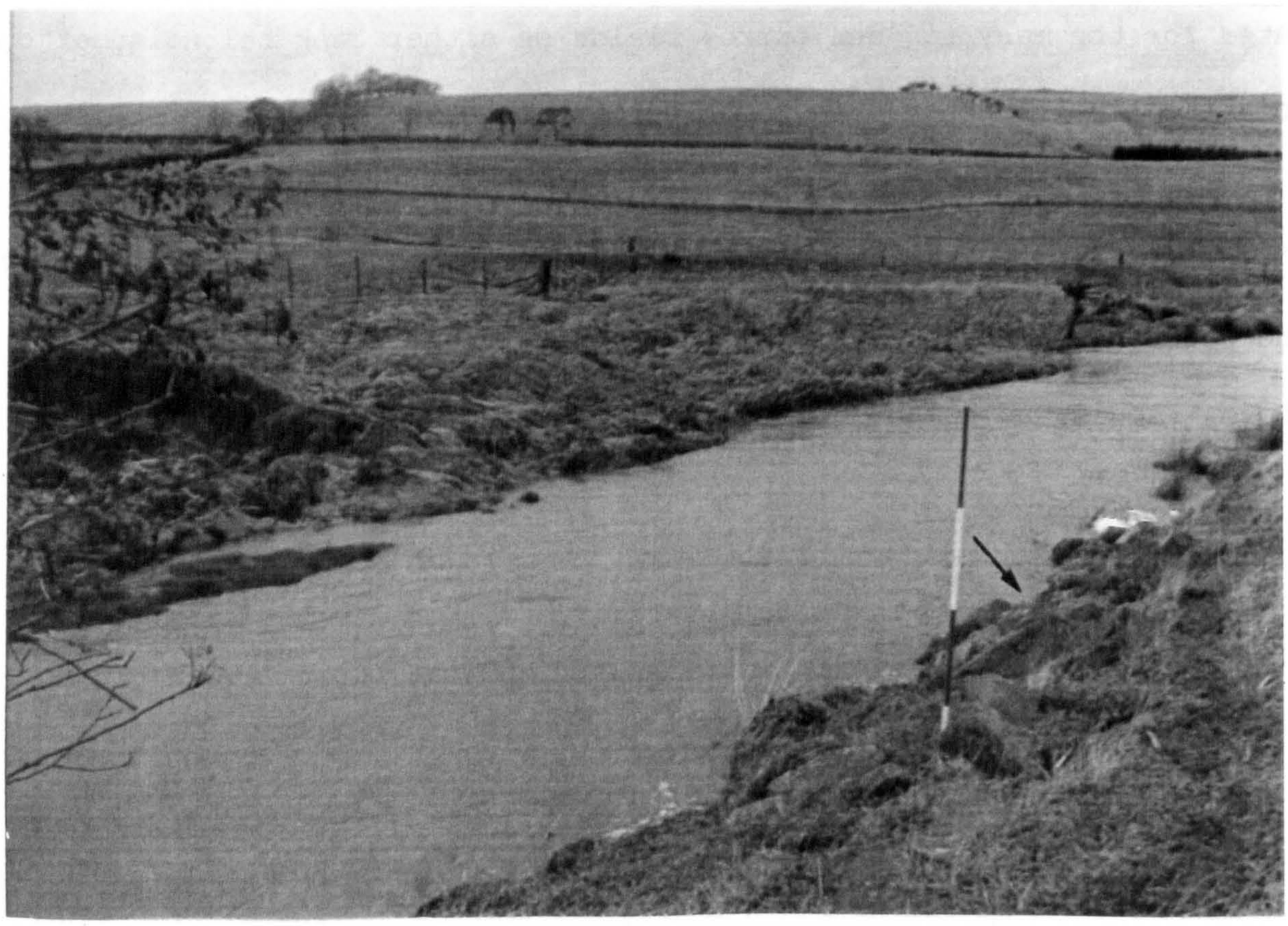


Plate: **49** Abberwick mill. Stone beginning 25cm left of ranging pole top seems to be cross-broached. This stone was re-used in construction of a farm building (north aspect), and may have a Medieval rather than Roman context.

Plate: **50** Probable rock dump on right bank of Aln, approx. 100m down the river Aln from Abberwick mill site, described above; south facing north.



Stage Three: Holne Park to Coe Burn. This stage consists of two Medieval mills and one weir. As Abberwick mill at NU 121 141 (A in figure 68)[1] now functions as a farmhouse, circumstances did not permit a thorough search of the precinct. Nevertheless, of the hundreds of stones examined, only one which was cross-broached (see plate 49) showed characteristics which could be Roman. However, as cross-broaching has been used from the Roman to modern period (Hill, 1981), this lone example is more likely to have been associated with the medieval Abberwick mill than with a Roman period structure. A weir associated with Abberwick mill used to collect water for the race (C in figure 68) also failed to reveal traces of Roman masonry.

Bolton mill lies about 1.5km upriver from Abberwick, at NU 118 131 (B in figure 68, plate 51).[2] The ancient buildings of the mill contain no Roman period stone. No traces of the weir which must once have served Bolton mill survive.

At a point 50m downriver from Abberwick mill at NU 1225 1415 (E in figure 68, plate 50), a quantity of stones was found on the east and right bank of the Aln. However, these probably represent a rock dump for the fields on either side of the Aln.

---

[1] Abberwick mill is first mentioned in 1571, when it was sold to John Shafto of Barrington by Henry Bellingham of Rottington, Cumberland, who acknowledged receipt on July 14, 1571 of thirty pounds in part payment (Hodgson, J C, 1904, 194).

[2] Bolton mill is mentioned first in 1234, when William, son of Austin of Bolton, rendered account for two shillings, and Siward the miller one shilling from a purpresture (Hodgson, J C, 1904, 205).

Plate: 51 Bolton mill, west facing east. Building on left re-built in part with Medieval masonry. The site lies on alluvial flood plain, now many meters distant from the narrow, deep course of the Aln flowing south to north at the tree-line.

Plate: 52 Mouth of the Coe Burn where it meets the Aln, NU 0900 1260. Note incision through banks of alluvial deposition. East facing west, approx.

Interpretation. Although the river Aln and its banks were inspected closely sometimes well beyond the modern course, no signs of Roman period hydro-engineering projects or stones displaying characteristics of Roman workmanship were identified.

The lack of Roman period stone in the river cannot be argued as a result of alluviation or river incision: according to the Piercebridge formula, 17 such dams would have been necessary, and river action could not have hidden or obliterated all trace of such structures. Indeed, many remains of Roman period bridges exist at Chesters and Corbridge along the Rivers North Tyne and Tyne resepectively, and these rivers have undergone as much, and perhaps more alluviation and incision than the Aln since the Roman period.

Alternatively, if all of the stones of the Piercebridge formula components were extracted from the river after the Roman period, some should have been found incorporated into buildings near the River Aln. Indeed, as discussed above (4.2.2; 4.3.2), stones from the Corbridge bridge-works have been found in numerous buildings near the banks of the Tyne. However, no such evidence exists in the buildings lining the Aln.

The lack of evidence for Roman period hydro-engineering and stone-work in the river or in river structures within and upon the banks of the Aln, suggests strongly against the development of the Aln with Piercebridge formula components in the Roman period.

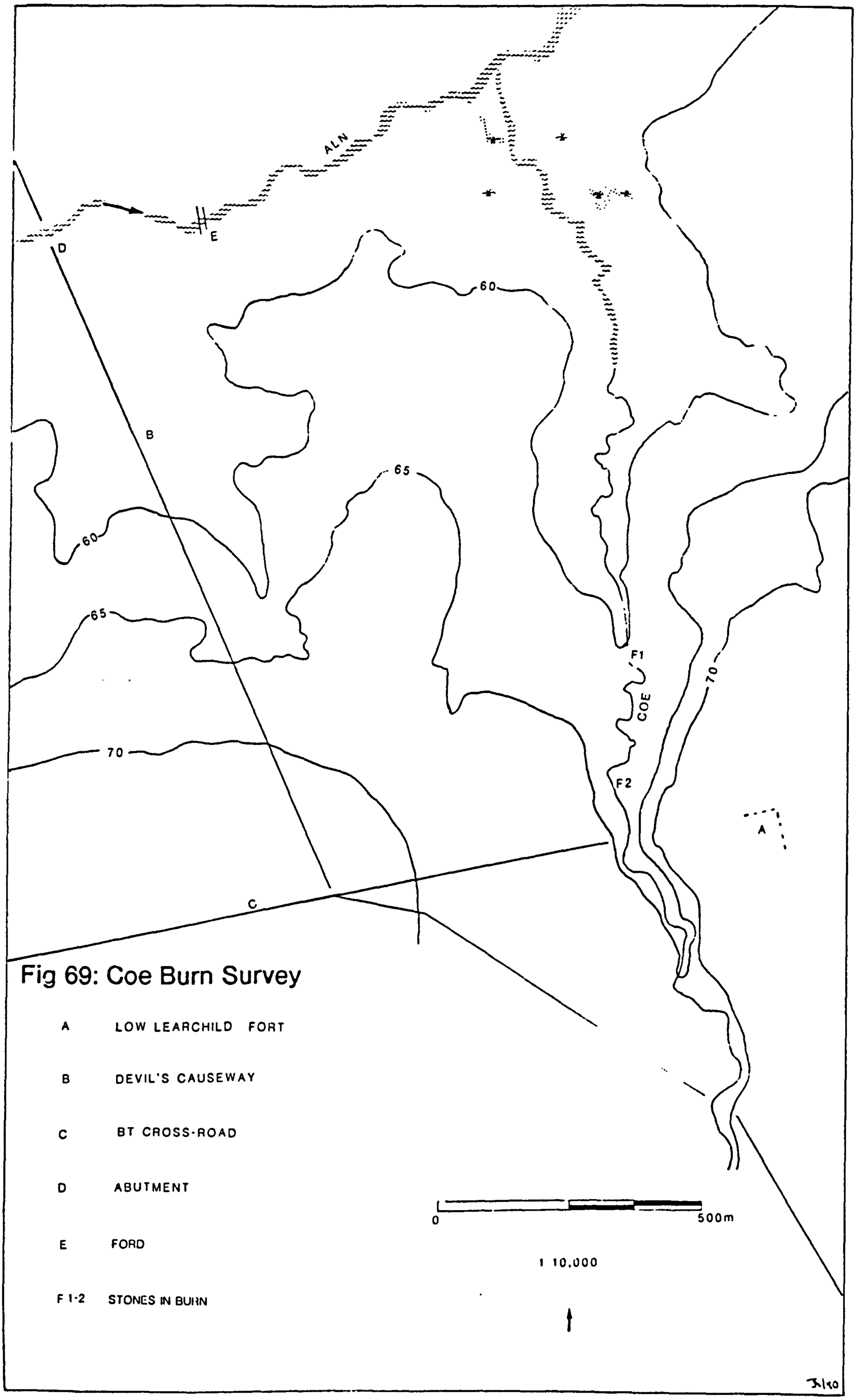


Fig 69: Coe Burn Survey

Survey II: The Coe Burn

According to the Piercebridge formula, having navigated the Aln, provisions would have either been unloaded from barges and carted down the Devil's Causeway, or the bargemen would have continued navigating the barges up the Coe Burn to the fort at Low Learchild. If the latter, navigation would have been made possible by a system of dams and locks constructed along the Coe Burn.

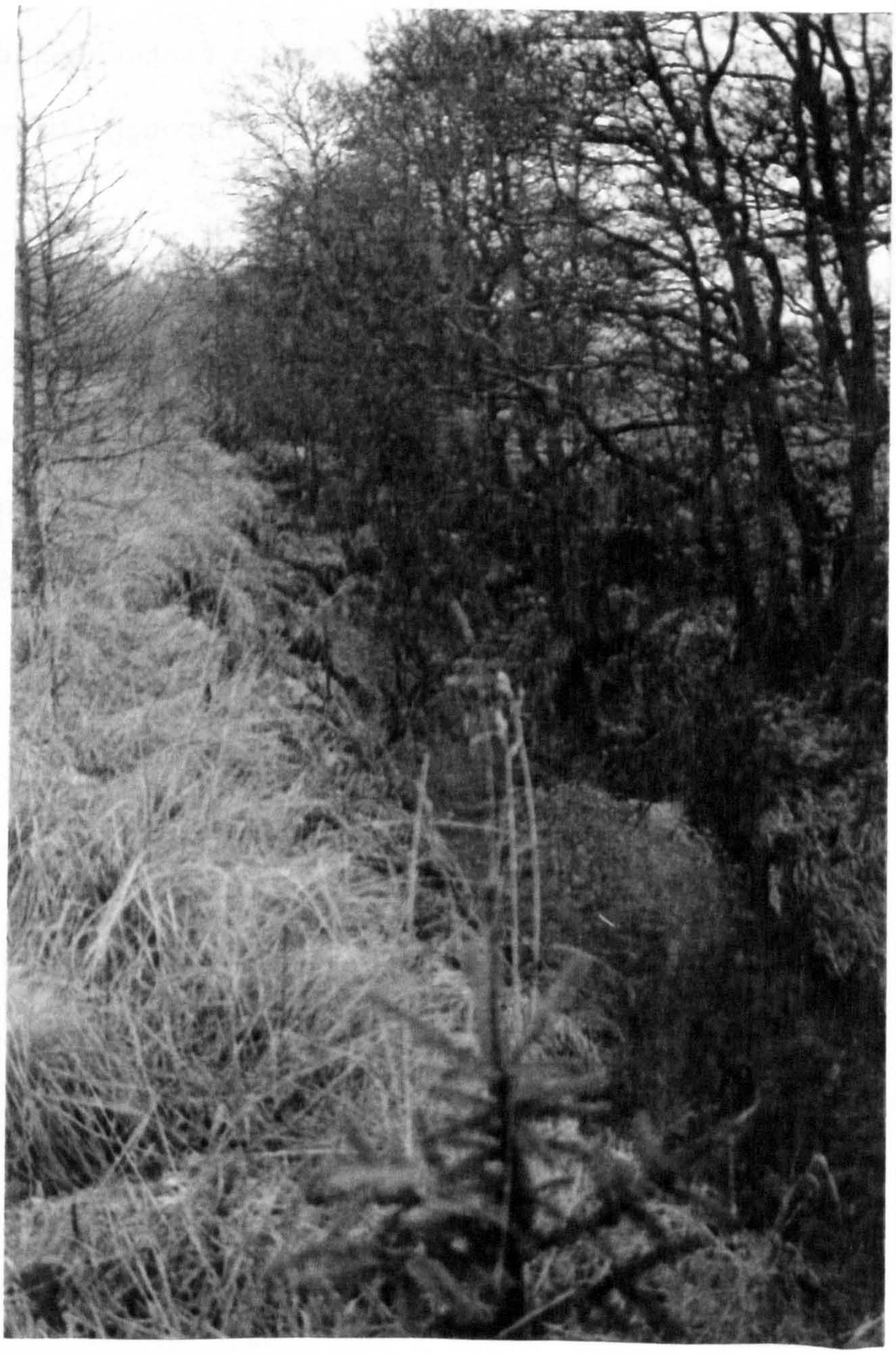
As with the Aln, the Coe Burn has incised through an alluvial bed to a great extent. In the mid-19th century, agricultural and mining activities ceased in the area of its main catchment, Callaly Moor, lying at 200-260 OD and south-west of Low Learchild. The moor thus became covered in heather and bracken so that the Burn's sediment concentration decreased, and it began incising through its valley fill (Cowley and Edwards, 1988).

However, similar to the Aln, high degrees of cultivation of the Moor in the Roman period (ibid.) would have rendered the Burn full of sediment and apt to alluviation, a process which had been continuing along the Burn from the Bronze Age (Macklin et al, forthcoming). Therefore, the Burn would have been wide, shallow, and prone to silting in the Roman period.

The confluence of the Coe Burn and Aln, at NU 0900 1260 (plate 55) consists of a large amount of alluvial deposit cut by the present channel

Plate:53 Coe Burn at NU 0960 1260, north facing south. Note channel incision through high banks of alluvium.

Plate:54 Coe Burn 50m down from Low Learchild Roman fort, north facing south. Note channel incision.



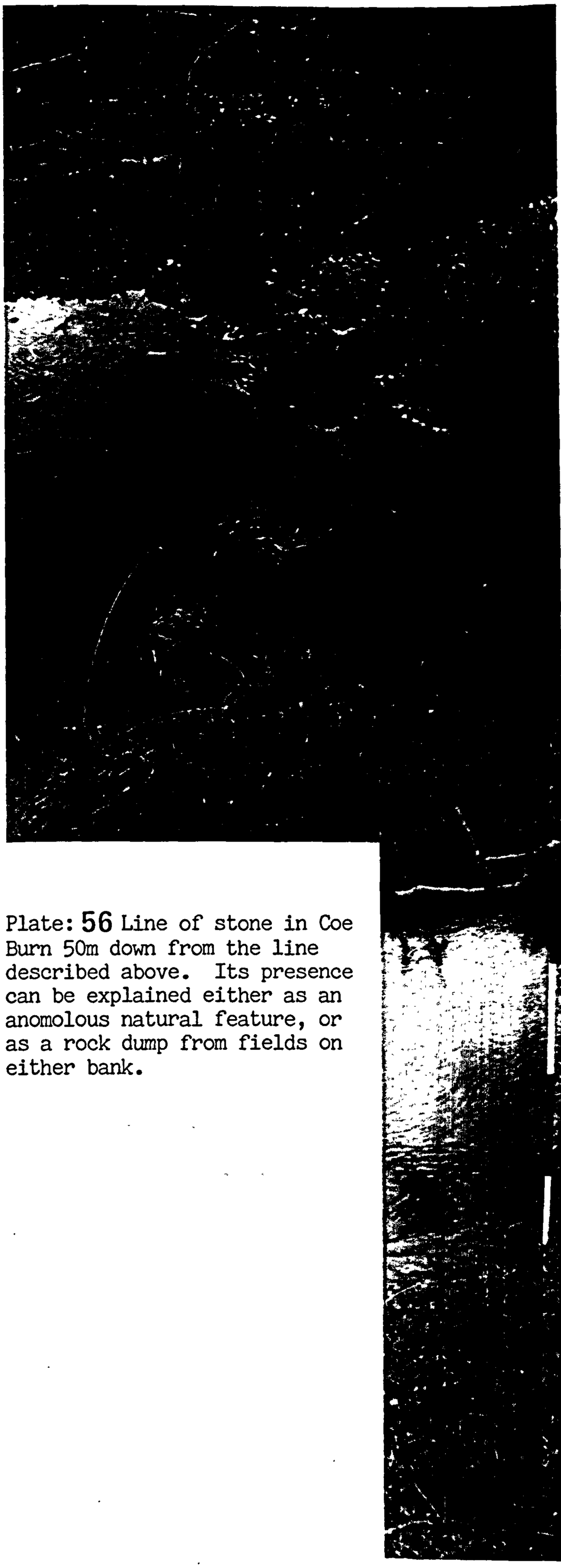


Plate:55 Stones in line across Coe Burn 10m down from Low Learchild Roman fort. Given the considerable depth of incision of the Coe Burn in the modern period, it is likely that these stones lie below the level of the Roman period Burn. Having penetrated through alluvial deposition, the Coe Burn has exposed a natural, anomolous line of stone.

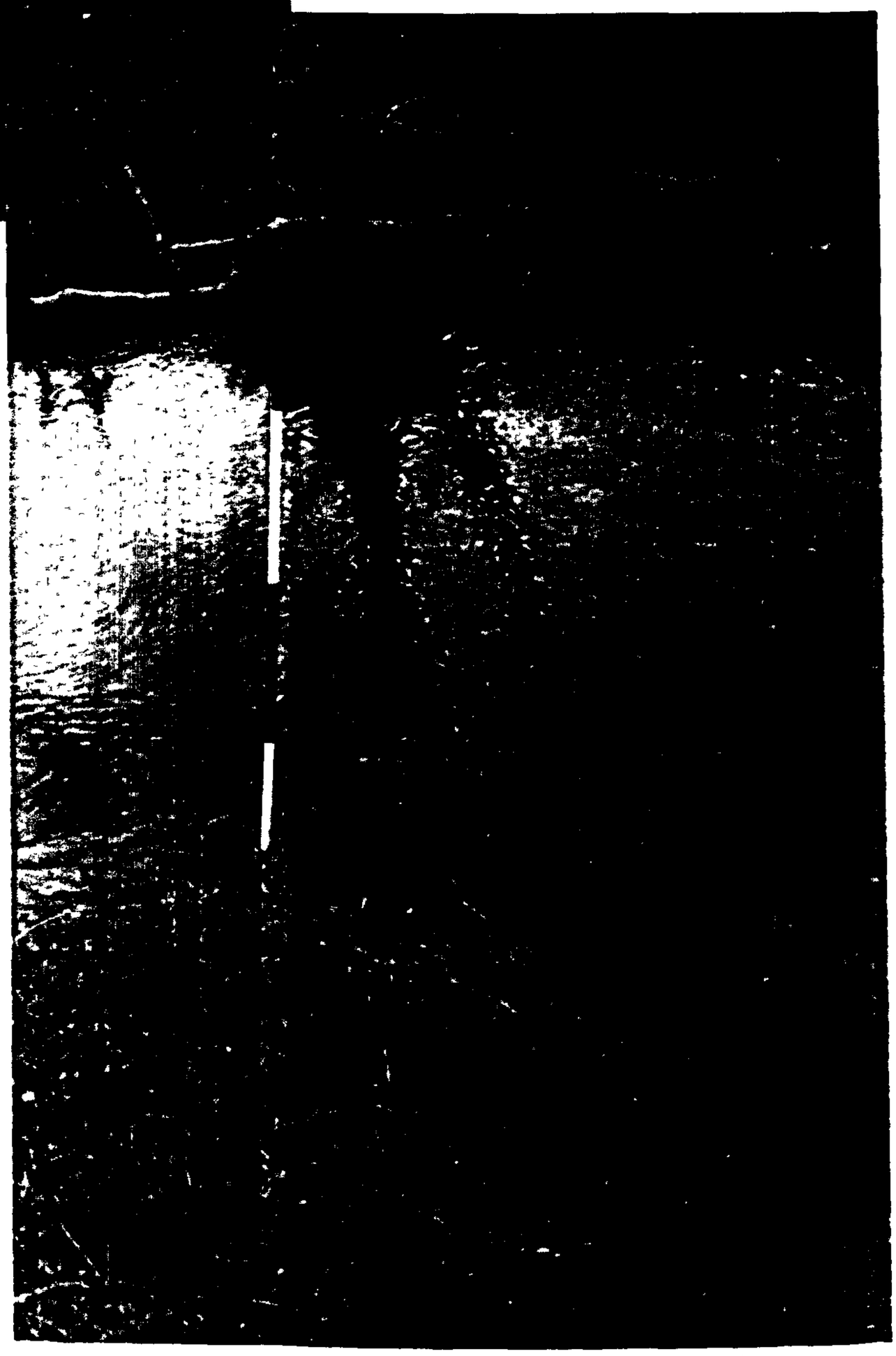


Plate: 56 Line of stone in Coe Burn 50m down from the line described above. Its presence can be explained either as an anomolous natural feature, or as a rock dump from fields on either bank.

5.4 CONCLUSION: EVIDENCE FOR THE PIERCEBRIDGE FORMULA

Evidence for the Piercebridge formula has been examined across ten sites in three areas of the North-east. At each site, structures identified in The Piercebridge Formula as components used in Roman period river development are otherwise.

Structures identified as originally Roman and then re-used at a later period seem rather to have been constructed in the post-Roman period. For example, the steep gradient at the termini, as well as the narrow channel widths suggests that 'by-pass canals' at Piercebridge were constructed to feed Medieval mills. At Bywell and Hylton, the 'pound-locks' have all the hallmarks of fish-locks built into weirs. Although the existence of Roman structures underneath is possible, the lack of other Roman structures in the area and the fact that the structures seem 'tailor-made' for the fishing industry, suggest that the structures were built originally as Medieval fish weirs. The 'by-pass canal' at Binchester is a Medieval to post-Medieval drainage channel dispersing colluvial run-off from the vertical rig-and-furrow and collected in a natural basin, while at Brinkburn, the track and bridge most likely were built at the same time as the Priory in the 12th century. A bridge would have served the many buildings of the Medieval occupation, while no evidence exists for a Roman period occupation.

In addition, certain structures identified as Piercebridge formula components are in fact natural features formed by river action. Indeed,

of the Burn. No structures of any kind can be detected at this point.

Above the confluence, the Coe Burn incises through sometimes very steep and high banks (see plate 53). At NU 0995 1150 (F1 on figure 69, plate 55), a group of stones lie in a line across the river. They are uncut, and likely represent a natural anomalous feature. In any event, given the incision of the Coe Burn since the Roman period, these stones probably would have been far below the level of the Roman period Burn.

At NU 0995 1120 (F2 on figure 69, plate 56), another group of stones in a line across the Burn's course again is probably a natural, anomalous feature.

Interpretation. As with the Aln, the total lack of evidence for the 7 dams necessary, according to the Piercebridge formula, to render the Coe Burn navigable by barges, proves that Low Learchild fort was not supplied along the Coe Burn according to the Piercebridge formula.

5.3.3 Conclusion: Low Learchild

At the site in Area 3 where evidence for Piercebridge formula components would be most expected, given the long overland supply routes and the early occupation period at Low Learchild fort, it seems they did not exist.

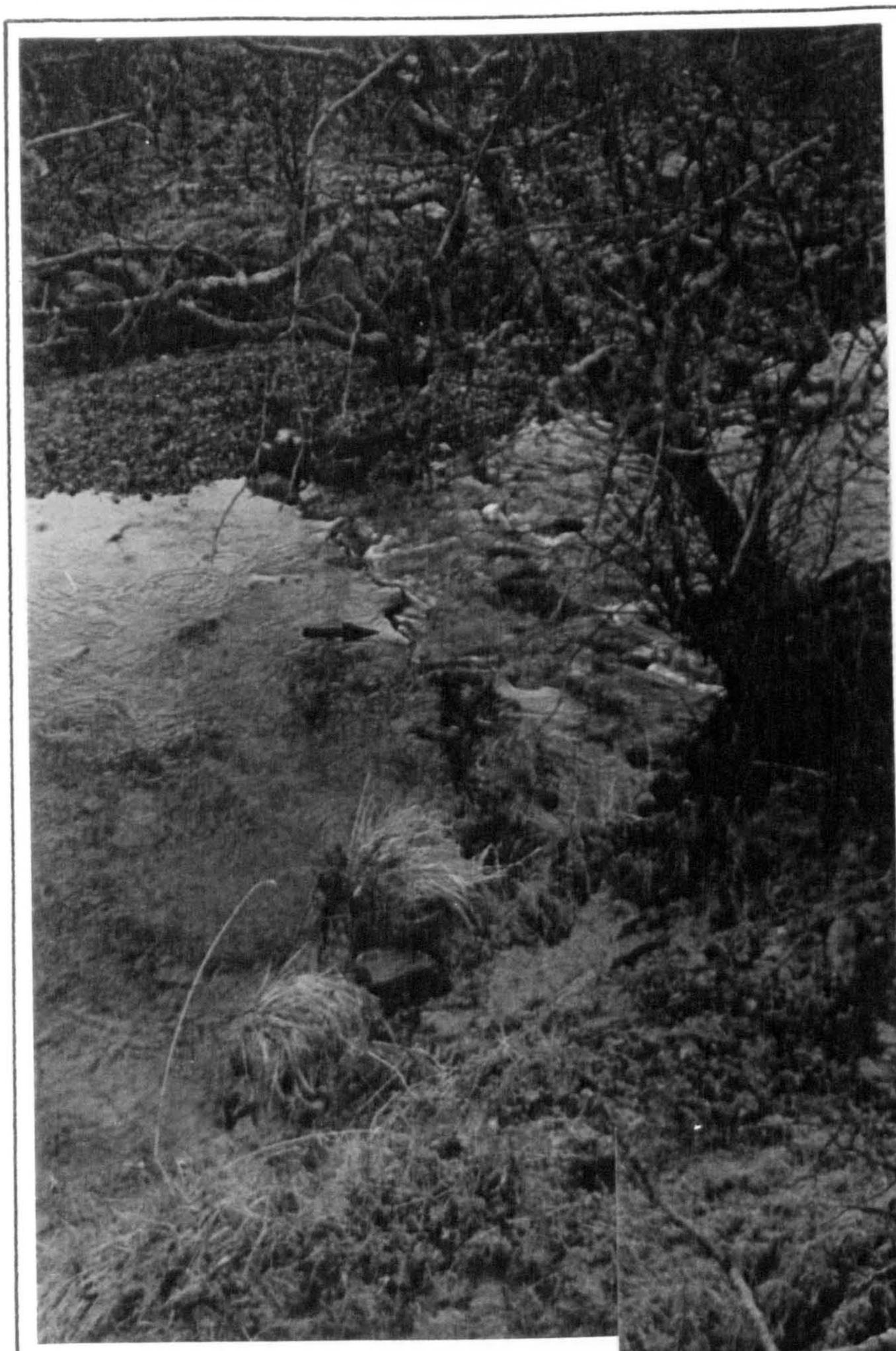


Plate: **55** Stones in line across Coe Burn 10m down from Low Learchild Roman fort. Given the considerable depth of incision of the Coe Burn in the modern period, it is likely that these stones lie below the level of the Roman period Burn. Having penetrated through alluvial deposition, the Coe Burn has exposed a natural, anomolous line of stone.

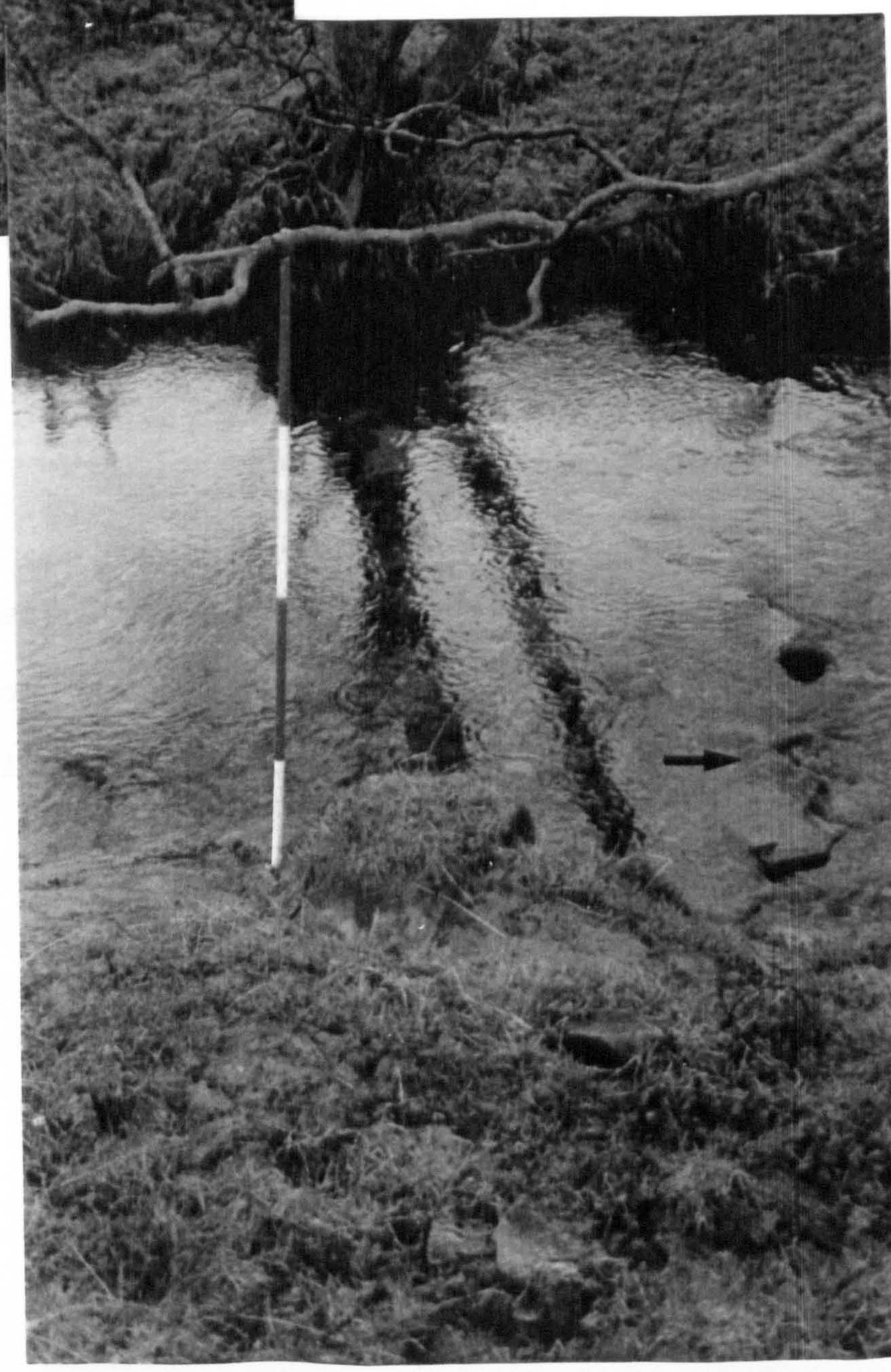


Plate: **56** Line of stone in Coe Burn 50m down from the line described above. Its presence can be explained either as an anomolous natural feature, or as a rock dump from fields on either bank.

the recent decrease in cultivation in the catchments of the North-east has resulted in less sediment concentration within the river regimes, so that these rivers today are fast and straight. The rivers have also cut narrow channels through deep layers of alluvial sediment deposited over the flood plains during previous periods of extensive cultivation and aggradation. In this context, the 'canal-barge harbour' at Bywell is rather a back-channel which has cut through the Tyne's flood plain between the left bank and point bar. Similarly, the 'canal' below the 'fort platform' west of Brinkburn is also a flood-plain back-channel cut through aggraded alluvia.

The recent incision into the flood plains of North-eastern rivers has also resulted in the formation of paleao-channels to either side of the present river channels. Again, the wide, meandering courses of these palaeo-channels reflect periods of high sediment concentrations within the river systems. In this context, the 'by-pass canal' and 'barge harbour' at Chester-le-Street are rather a course of the River Wear formed when cultivation within the Wear catchment was much more extensive than it is today. Similarly, the 'by-pass canal' at Risingham is a palaeo-channel of the Rede cut at least 200 years after the Roman period, while the 'barge-wharf' is the remains of a soliflucted till terrace 'trimmed' by the scouring of two former channels of the Rede. Finally, the 'barge passing-place' at Piercebridge is in fact the original course of the Dyance Beck before its flow was re-directed down a mill-race most likely cut in the Medieval period.

The processes of incision and formation of what have become paleao-channels along the river courses are generated to a large extent by the sometimes tempestuous flooding of the North-eastern river systems. Indeed, the 'fort platform' at Brinkburn was formed specifically by such periodic flooding above a bend in the Coquet where the river passes through a 'chute' between steep cliffs.

Dating evidence for Piercebridge formula components is often tenuous. The dating of structures by the position of artefacts found on a river bed or flood-plain is often rendered untenable by river action: artefacts found near the 'jetty' at Corbridge, and at least some of of the artefacts found under the first bridge at Piercebridge could have been washed from the banks and deposited at any point since the Roman period. As for Roman period stone, its existence at Bywell does not indicate necessarily Roman period structures or occupation. Indeed, there is not enough contemporary stone or artefacts on the site to assume a Roman period occupation, and its transport from the ruined bridge at Corbridge 10km downriver to Bywell in the Medieval period is far more likely. Similarly, the stone in the 'jetty' at Corbridge, replete with lewis-holes and cramp-holes common to Roman period bridge-work, almost certainly belongs to the Roman bridge at Corbridge, and possibly even its superstructure. At Risingham, inscribed stones reportedly found in the 'barge wharf' most likely represent tumble from a reconstructed fort rampart.

In Area 1, and lying within the province and the Roman Empire, Piercebridge - the 'flag-ship' of the Piercebridge formula - as well as two other sites listed as formula sites - Chester-le-Street and Binchester - have revealed no archaeological evidence supporting the Piercebridge formula.

Perhaps more telling is the lack of evidence for Piercebridge formula components in Area 2. As the formula focuses on supply of Roman military personnel, and as there were more personnel in this area than anywhere else in Britain for most of the Roman period, if the Piercebridge formula was indeed carried out, evidence for it should have been found in Area 2. However, at Bywell and Corbridge, both lying along the major water route of Area 1 - the Tyne - no such archaeological evidence was recovered. Further, while frequent mention is made of overland transport, nothing is mentioned of the Piercebridge formula within the corpus of the Vindolanda writing tablets.

As for the forts in Area 3 situated north of the Wall and outside the province for most of the Roman period, again Piercebridge formula components do not exist. Risingham, a fort lying on the Rede and used in the Piercebridge Formula to illustrate the exploitation of rivers over many kilometres, has produced no archaeological evidence which supports the formula. The same can be said for Brinkburn, situated many kilometres along the Coquet from its mouth. Low Learchild, situated further along the road system from a supply base than any fort in this survey area, is the likeliest candidate for the Piercebridge formula in

the North-east. However, not a trace of Roman river development was found from the mouth of the Aln to the foot of the fort.

The one piece of evidence supporting the Piercebridge formula is the likelihood that South Shields, located at the Tyne's mouth, functioned as a supply base receiving sea-borne supplies throughout the Roman period. However, when taken in conjunction with the lack of evidence further up the Tyne, it appears that South Shields was not a major cog in a supply system based on rivers developed with Piercebridge formula components.

In total, none of the sites examined across the North-east has produced evidence for river-barge supply according to the Piercebridge formula. It is not enough to say that all evidence has been buried or destroyed, or that the components have been completely quarried for use in other structures. Indeed, if river dams were to withstand the tempestuous flooding in the North-east, they would have had to have been at least as robust as the bridges, and, given their essentially inflexible structures, perhaps many more times stronger than bridges. However, although the remains of <u>in situ</u> bridge-works have allowed positive identification of various Roman bridges in the North-east, nothing similar for river dams has been recovered. This is especially conspicuous, given that bridges would have been far fewer in number. That no evidence has been found in the vicinity of ten sites in this survey area for even one of the many dams necessary to render the formula functional, proves that the Roman military did not develop the rivers of the North-east according to the Piercebridge formula.

CHAPTER SIX

AN ALTERNATIVE METHOD OF SUPPLY TO FORTS IN THE NORTH-EAST

As supply of forts in the North-east, according to the Piercebridge formula, would not have been considerably more efficient than overland transport, it is not wholly surprising that no evidence has been found which supports the formula at ten sites across the North-east. Having thus dismissed the Piercebridge formula, it now remains to present an alternative method of supply to Roman forts in the North-east.

Supplies transported to forts in the North-east include raw materials, food, and manufactured commodities[1] and can be divided roughly into two groups: those which were transported from long distances away, and those which could have been produced within the North-east. As for the former, the identification of supplies transported over long distances to the North-east relies foremost upon artefactual recovery. Analysis of non-perishable 'tracer' artefacts recovered in the North-east such as pottery (fine and coarse-ware), amphorae, coinage, glass, stone-work (querns), and metalwork (mirrors), can often indicate the specific or general area of production in other areas of Britain, North-west Europe or around the Mediterranean. The identification of other supplies transported over long distances to the North-east can be inferred. As a

---

[1] For a comprehensive break-down of the necessary manufactured commodities, see Breeze, 1984.

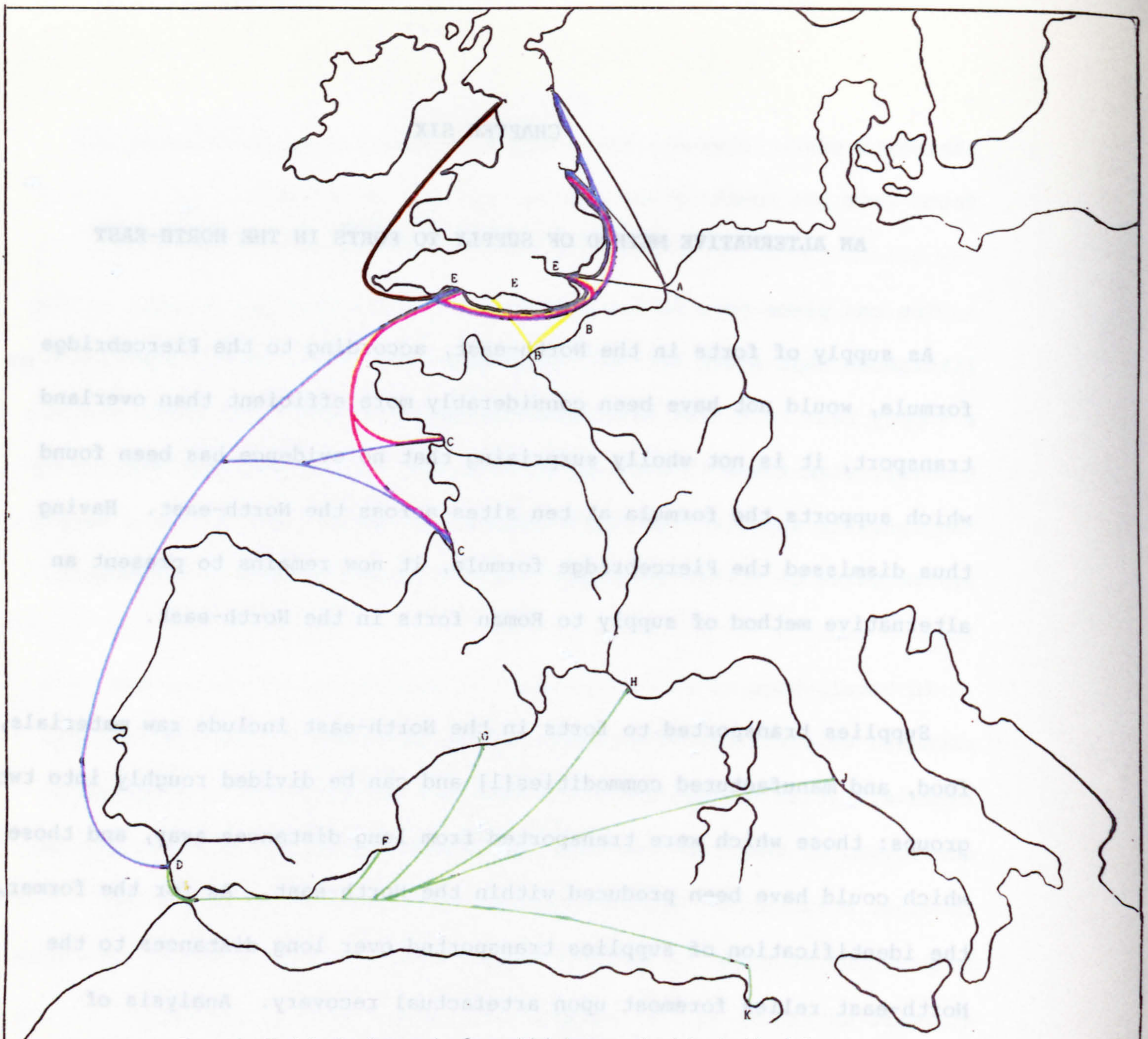


Fig 70: Thematic Sketch showing ports from which known materials destined for North-east ports were obtained, and proposed routes over which materials were shipped to ports serving the North-east.

Supplies

A Dutch ports

Grain
Samian
Mirrors
Querns
Salt
Glass
Wine
Fish sauce (?)
Mediterranean Products via Rivers Rhone-Rhine:
- Fine Table-ware
- Precious Metals and metalwork
- Amphorae of Wine, Fish sauce, etc.
- Textiles and animal skins
- Medicines
- Luxury Foods

B French Channel ports

Mediterranean Products via Rhone-Seine
- Those mentioned above
- Soldier's Pay (?)

C French Atlantic ports

Samian
Wine
Mediterranean Products via Garonne-Bordeaux, or Rhone-Loire

D South-west Spanish coast port

Baetican amphorae
- Olives and oil
- Wine
- Fish Sauce

Mediterranean Products via ships sailing from Mediterranean ports through Gibraltar

E South British coast and Thames estuary

Grain
Cooking-ware
Salt
Glass
Oysters
Textiles (?)
Leather, metal, woodwork (?)
Mediterranean Products via ports mentioned above

Some Mediterranean ports:

F New Carthage

G Tarraco

H Massilia

J Ostia

K Carthage

Routes

Dutch Coast ports ——

French Channel ports ——

French Atlantic ports ——

South-west Spanish port ——

South British coast and Thames estuary ——

Mediterranean ports ——

A/91

general rule, most manufactured items used in the North-east would have been supplied from outside the area: indeed, manufactured goods generally required skilled workers organized in 'factories' (Higham, 1989, 164), for which the North-east lacked both the capital and skills. Valuable material such as silver plate or bronze may well have been supplied to the North-east but subsequently perished because of their value as scrap. Supply of other perishable items can be inferred because of their recovery in other areas of Britain. Barrels, silk and other textiles, glass, luxury foods, leather and woodworking may have been transported over long distances to the North-east but so far have remained archaeologically invisible. Finally, the supply of certain items such as salt to the North-east can be inferred by epigraphic evidence.

The transport of supplies to the North-east would have been carried out over the sea, road network, and possibly North-eastern river systems.

6.1 SEA-BORNE TRANSPORT

A sea passage to a port in or near the North-east would have greatly decreased the volume of supplies which may otherwise have necessitated overland transport. An assessment of the logistics of sea-borne transport of materials to the North-east involves a determination, as far as possible, of the ports from which the supplies were shipped. Once collected in various ports, supplies destined for the North-east would have been transported for the most part by private merchants, upon at least two types of ships over routes either directly to the North-east,

or indirectly via South British ports. Finally, supplies destined for the North-east would have been received at four different ports: York, the Solway Firth, possibly Berwick-upon-Tweed, and South Shields.

6.1.1 Origin of Supplies: Ports

A determination of the ports of origin for supplies shipped to the North-east relies heavily upon non-perishable 'tracer' artefacts mentioned above. However, the limitations of tracers as sources of evidence for long distance supply must be stressed. As will be discussed, in terms of bulk, the ratio of such manufactured items compared to perishables recovered upon wrecks excavated in the Mediterranean is very low (Pucci, 1983), so that "a healthy trade in perishables and raw materials could well have been carried on without leaving any trace in the archaeological record" (Fulford, 1978, 62). Therefore, such limitations render very difficult a comprehensive quantitative or qualitative assessment of supplies shipped to the North-east from various ports. Overcoming these limitations, if at all possible, would require an indepth analysis of each tracer artefact. However, as available space will not allow more than a brief discussion of each artefact, the evidence from tracers will be used below to indicate at the most the origin and time period at which the ports supplying the North-east were used.

The ports are situated along the Dutch North Sea coast, most particularly those near the mouth of the Rhine; along the French Channel

coast at Bordeaux and the mouth of the Seine; along the French Atlantic coast at the mouths of the Loire and Garonne; at Gades on the south-west Spanish coast, which would have received ships from Mediterranean ports; and along the South British coast and Thames estuary.

Dutch Coast

Early period. Until local or British production had become established, Rhenish goods such as quern stones, glass, and barrels holding various commodities may have been shipped to the North-east from a Dutch port.

It seems that the army of the Conquest and immediate post-Conquest periods was supplied with Mayen lava stones. These stones are lighter and far more efficient than the bee-hive querns used by the native population in the North-east, and have been recovered on many military sites in north Britain, the best examples of which have been found at Newstead (Curle, 1911, 145), Binchester (Hooppell, 1891, 40), and Vindolanda (Welfare, 1985, 156-7). As will be discussed, soon after the initial period, importation of Rhenish quern stones would have been replaced by quern stones produced in the North-east from local sources of millstone grit and granite.

Excavations at Vindolanda have shown that glass articles supplied to the North-east include tablewares, containers, beads, gaming pieces, stirring-rods, hair-pins, and bangles (see Price, 1985), at least some of

which were probably manufactured at an early period in factories in or near Cologne. First, Cologne, the capital of Germania Inferior, was problably the most important glass-making centre in north-west Europe (Fulford, 1977b, 63). Second, inscribed bottles found at Silchester (CCA) are thought to have been manufactured at Colonia Claudia Agrippinensis (Price, 1978). Although estimates can be misleading,[1] it seems that from the Flavian period onwards, imports of Continental glass seem to have decreased (Price, 1978, 74). Indeed, the factories of the Rhineland area do not seem to have continued in operation beyond the 1st and 2nd centuries (Doppelfeld, 1966, 11-16).

Much evidence suggests that barrels were imported from the Rhineland to Britain during at least the 1st and 2nd centuries (Wilmot, 1982, 47-9). Barrels are thought to have held wine, but may have held a range of other items (Fulford, 1984, 132), including salt, salted meat, salted fish, or fish sauce. Some barrels found in Britain, as well as those in Germany and Belgium were made of silver fir and larch (Boon, 1975). Although the natural habitat of silver fir is wide and difficult to pinpoint for the Roman period (Peacock, 1978, 51), larch is found only in the Alps. In addition, the distribution of extant barrels in North-western Europe follows the line of the Rhine and Danube (Ulbert, 1959), while British examples have been found only on the eastern side of the country (Fulford, 1977b, 59).

---

[1] Once broken, Continental glass vessels may have been melted down to make new vessels, window glass, or beads (Price, 1978).

That the barrels found in Britain held wine is supported by epigraphic evidence attesting to wine merchants at the Scheldt estuary[1] during the 2nd century.[2] Bogaers (1971b, 42) argues that negotiatores vinarii are represented by one dedicant at Colijnsplaat on the basis of reliefs on the altar dedicated by him to Nehallennia: on its side are vine scrolls and beneath the inscription is the representation of a barge laden with barrels.

In addition, these barrels may have held salt supplied to the North-east from the 2nd century. Four inscriptions on altars (AE 1973, 362; AE 1973, 364; Bogaers 1971b, 37; AE 1973, 378) from Colijnsplaat mention merchants involved in the salt trade - negotiatores salarii. Since three of these men lived in Cologne, Bogaers (1971b, 41) suggests that the trade was an Imperial monopoly centred in this city.

As for these barrels holding fish sauce, negotiatores allecarii, or traders in fish sauce, also appear on a dedication at Colijnsplaat (A.E. 1973, 365; 365; 375; Bogaers, 1971b). If not in barrels, fish sauce may have been shipped in amphorae: as will be discussed, the Rhine may have been a major conduit for Mediterranean commodities shipped in amphorae.

---

[1] Colijnsplaat and Domburg (25km to the west) are on the north coast of the Scheldt estuary, at Noord-Beveland and Walcheren, respectively, and both had shrines dedicated to the goddess Nehallennia near important harbours.

[2] Although the altars date to the late 2nd, early 3rd centuries (Hassall, 1978), by this time the scale of operations had probably declined (Rouge, 1966, 274-283; Greene, 1979, 104), and it is likely that the altars reflect trade flourishing throughout the 2nd century.

3rd century. As many as 17,000 soldiers in the North-east would have required at least 5,584,500kg (see Appendix H-1) grain per year, and it seems that some of these requirements were satisfied at least in the 3rd century by shipments from the Netherlands. Carbonized seed grains (31418 grains in total) recovered from a 3rd century granary context at South Shields represent three types of cereal grain: spelt (triticum spelta), bread (triticum aestivo-compactum), and barley wheat (hordeum vulgare) (van der Veen, 1988, 364). Spelt and bread wheat appeared in similar quantities (8109 and 6120 grains respectively), while the small amount of barley wheat suggests a contaminant.[1] Spelt is hulled, while bread is a naked wheat, and because they would have required different processing procedures,[2] it is unlikely that they would have been grown together.

By the late Iron Age, spelt wheat had replaced emmer in the North-east [3] and by the Roman period, it predominated across Britain. Although bread wheat had been grown from the later Neolithic, it was not an important crop in Britain until the Saxon period.[4] Virtually all carbonized grain assemblages from grain store deposits and settlements in Roman Britain contain only very small quantities of bread wheat.

---

[1] It may have occurred as a weed in the wheat crop, as a left-over from a previous harvest (van der Veen, 1988, 364).
[2] Indeed, the spelt grains had been dehusked, and only 9 per cent of the grains would still have been enclosed by their glums when the crop was delivered to the site (van der Veen, 1988, 359).
[3] Spelt wheat has been recovered at Thorpe Thewles, Coxhoe, and Stanwick (van der Veen, 1987; van der Veen and Haselgrove, 1983).
[4] Roman sites in Scotland have consistently produced very small numbers of bread wheat, while in the North-east, bread wheat has not yet been found. However, its absence may be explained by the low number of Roman period grain assemblages to date (van der Veen, 1988).

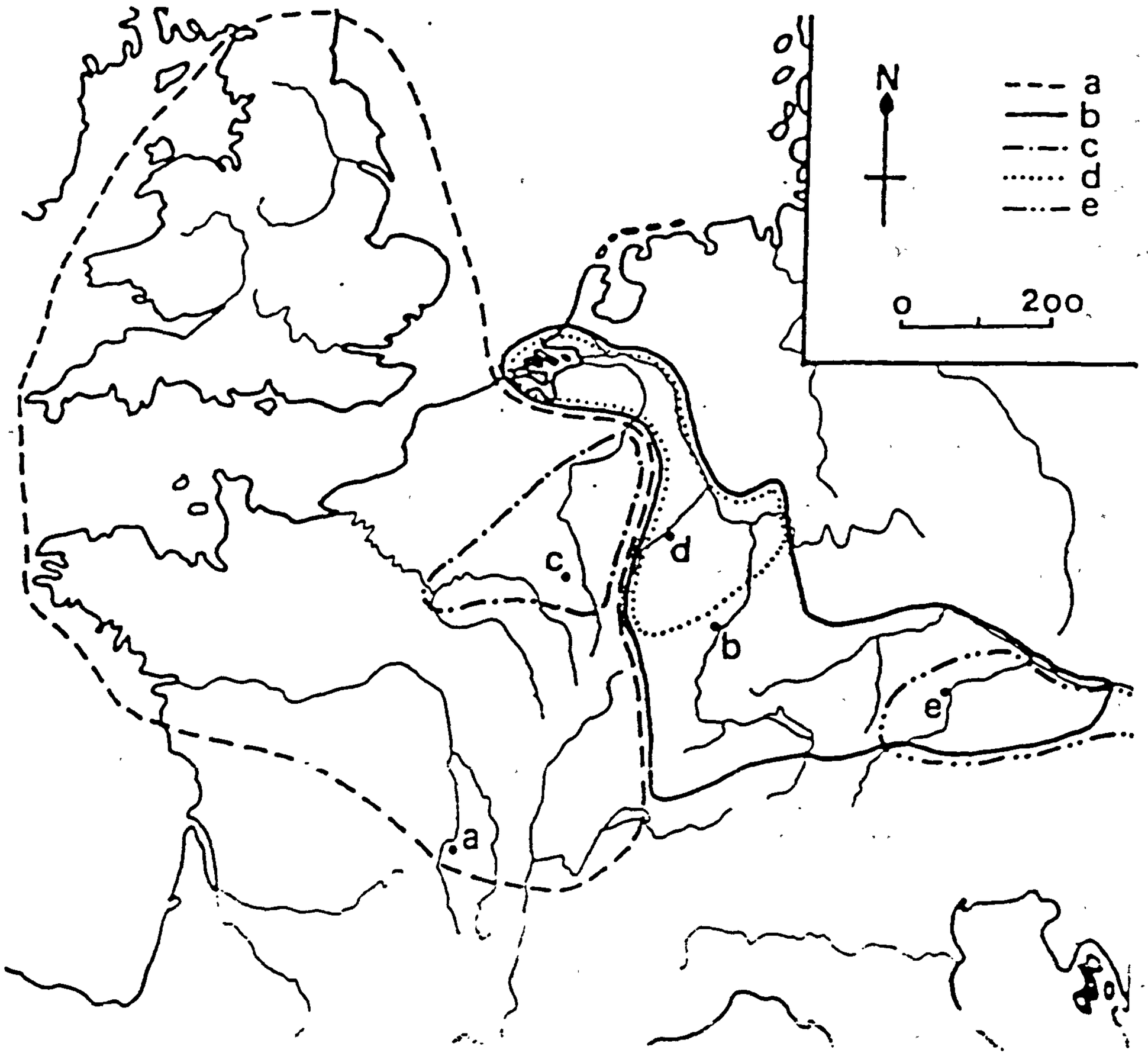


Fig 71:

Map showing generalised distribution areas of the principal samian ware kiln centres of the late second and early third centuries.
Key: a, Lezoux; b, Rheinzabern; c, the Argonne; d, Trier; e, Westerndorf/Pfaffenhofen.

From King, 1981.

However, at South Shields, the high number of bread wheat grains recovered compared to spelt suggests that bread wheat was very important at the fort.

The reverse is true in the Netherlands, where a number of Roman sites have produced very large, more or less pure bread wheat assemblages,[1] with very small quantities of spelt wheat. Therefore, during the 3rd century at least, bread wheat was most likely imported from the Netherlands in grain ships to the granaries at South Shields. However, as discussed in Appendix H-3.3, 3rd century grain importation from the Netherlands is not likely to have continued long. Indeed, due to decreased grain production resulting from soil exhaustion and barbarian invasions, the Lower Rhine army began to rely on imported grain by the middle of the 3rd century.

The recovery of stamps in this survey area attests to the supply of samian to the North-east from kilns along the upper course of the Rhine in the north-east Gaulish region (see figure 71), presumably via a Dutch port, by the end of the 2nd or early 3rd century.[2] The distribution of such pottery across the North-east will be discussed below (6.1.2).

---

[1] Maastricht, Aardenburg, Ouddorp, and Valkenburg; see Appendix H-3.
[2] For a full analysis of most of the East Gaulish samian wares found in the North-east, see Bishop and Dore, 1988.

4th century. Pay for troops in the North-east would have represented considerable bulk (discussed below), and it seems that during the first half of the 4th century most of this coinage was sent from the Rhine to Britain. From ca 294, Trier began supplying coinage to Britain, and from ca 330-348 this supply accounted for 60-80 per cent of the total coinage into Britain, only to drop-off dramatically ca 356 (Fulford, 1977b, 68).

Entire Roman period. Mirrors may have been shipped from a Dutch port throughout the Roman period. Two silvered bronze mirrors recovered at Corbridge are similar to those found in the region of the Lower Rhine (Lloyd-Morgan, 1977, 335): some 45 per cent of the Corbridge-type mirrors have been found in the province of Lower Germany, with nearly 30 per cent of the total coming from Nijmegen alone (ibid.).

The mouth of the Rhine also may have received goods destined for the North-east which had been barged along the river systems from the Mediterranean. Dressel 30 (Callender 10) amphorae recovered in Britain seem to have been produced in various small factories at the mouth of the Rhone, and the concentration of these amphorae along the valleys of the Rhone and Rhine perhaps indicates the route over which amphorae were supplied to Britain (Peacock, 1978, 49-51). Although not the quickest route through Gaul (discussed below), Britain may not have been the primary commercial objective: Dressel 30 amphorae which reached Britain may have represented the surplus of supply after the demands of population centres and military installations along the Rhine had been satisfied (Peacock, 1978, 51). Indeed, this route included more cities

and military installations than any other route through Gaul (Greene, 1986, 40). Dressel 30, then, may represent a proxy for the shipment of other supplies from the Mediterranean (discussed below) along the Rhône-Rhine route to a Dutch port for eventual distribution to the North-east.

In total, the North-east received tracer artefacts throughout the Roman period shipped from a Dutch port. Such an entrepôt would have received goods produced in the Lower Rhine region, such as mirrors and possibly grain, and the upper Rhine region, such as querns, glass articles, wine, as well as commodities transported along the Rhône and Saône from the Mediterranean, such as amphorae, and the interior of Gaul, such as La Graufesenque and Central Gaulish samian ware (discussed below).

French Channel Coast

Similar to the Dutch coast, the French Channel coast may have received supplies destined for the North-east which had been transported down the River Seine from Central Gaul or perhaps from the Mediterranean. Strabo's third and fourth journeys through Gaul (Geog 189) comprises a barge passage along the Rhône and Saône, ox-wagon past Dijon to the Yonne and barge down the Seine to the Channel. Whereas the third journey terminates at the Seine mouth, the fourth journey departs from the Seine and includes a cart journey to Portus Itius (Boulogne), in the territory

of the Morini.[1] Both journeys would have been relatively cheap and safe: on the basis of Duncan-Jones' transport cost index (discussed above, 2.2.3), the Rhône-Seine route is the third cheapest across Gaul (Peacock, 1978, 49); although not as cheap as the Garonne-Bordeaux route, a port along the French Channel coast would have provided access to the shortest, and therefore safest sea route to Britain from the Continent.

The fact that the Rhône-Seine route was perhaps the safest journey to Britain from the Mediterranean may have recommended it as the route over which valuable and expensive articles were transported to Britain. Indeed, soldiers in the North-east may have received pay from Rome via a port on the French Channel coast (Hobley, 1989, 72), at least until the reign of Severus.

Estimating the quantity of coins imported to pay the stipendia in the North-east requires a determination of the total annual coinage requirement. From the Domitianic to Severan periods, auxiliary soldiers received coinage in the form of aes, consisting of sestertii (HS), dupondii, or asses (Hammond and Scullard, 1970, 262).[2] Stipendia varied according to whether the soldiers were equites or pedites: the former received 800 HS, or 2400 dupondii or asses each annually, while pedites received 400 HS or 1200 dupondii or asses each (Hammond and

---

[1] On the basis of its mention in the ancient sources (Caesar B Gall 5.2; Pliny the Elder HN 4.122), as well as its archaeologically-attested Roman period lighthouse (Suetonius (Caligula 46), Bologne seems to have been a more important port than the Seine mouth.

[2] One denarius equalled four sestertii, or twelve asses or dupondii.

Scullard, 1970, 1014; Walker, 1988, 337). As listed in Appendix A, over half of the soldiers in the North-east were pedites: therefore, an average of 1800 asses or dupondii represents the maximum amount of coins necessary in the North-east for each soldier annually. In total, the maximum number of coins needed to pay 17,000 troops in the North-east in one year would have been 30,600,000,[1] and numismatic evidence suggests that such coinage was transported to the military in the north of Britain in bulk shipments (Robertson, 1983, 429). However, two factors would have dramatically reduced the above estimate for the total amount of coinage supplied.

First, until the late Empire, much of a soldier's stipendium was deducted for payment towards food, clothing, boots, socks, arms, armour, hay, horses, and tents (Breeze, 1984, 274), so that it would not have been necessary for the army to have had on hand the full amount of coinage owed towards each soldier's stipendium at any one time. Second, on the basis of a study of coins from the sacred spring at Bath and Coventina's Well at Carrawburgh on Hadrian's Wall, it is argued (Walker, 1988) that until the middle of the 3rd century, Britain was a 'closed' monetary system. Certain issues of aes coinage were produced in Rome specifically for use in Britain, and on the whole, coinage was not collected from neighbouring provinces and transported to Britain; once in Britain, such coinage remained within the province (ibid., 295). In

---

[1] At 10 grams per as (Hobley, 1989, 72), this would have amounted to 306 tonnes of coinage per year.

addition, evidence suggests that some coinage may have been produced within Britain during this period. Indeed, as much as 20 per cent of Hadrianic asses were casts of genuine coins, possibly produced in the Caerleon-Usk area (Boon, 1974; Walker, 1988, 291), while the rough and lumpy fabric of the 'Britannia' issue of Antonine period asses suggests that they were minted in Britain with dies sent from Rome (Todd, 1966; Walker, 1988, 296).[1] Finally, aes coins remained in circulation for very long periods. The 8 aes hoards from Britain buried after 260 reveal that more than 90 per cent of the coins were over 70 years old and 10-30 per cent of the coins were over 130 years old (Reece, 1974; see also Casey, 1988, for coins at Corbridge). Therefore, although supplies of aes were transported frequently to Britain until 197, much of the coinage used to pay stipendia would have been drawn from that already circulating within Britain. Indeed, it has been estimated that the annual import of aes into Britain during the Antonine period averaged 108,000 HS (324,000 dupondii or asses) (Walker, 1988, 304), or 1.06 per cent of what has been estimated above.[2]

By the 3rd century, it appears that aes coinage ceased being supplied to Britain, with soldier's stipendia paid in denarii (Casey, 1988, 143; Walker, 1988, 300), or aes still in circulation (Robertson, 1983, 426). The greater value of denarii compared to aes would have meant

---

[1] However, recent examination of the Antonine Britannia asses at Corbridge have shown that many were not overly rough in manufacture (Robertson, 1983, 423).

[2] At 10 grams per as (see note above), this would have amounted to 3.24 tonnes of coins.

transportation of far fewer coins from Rome to Britain in the Severan period than during earlier periods. In addition, it seems that a substantial number of coins were cast within Britain during the Severan period (Walker, 1988, 301).

Although the supply of aes from mints in Rome to Britain was resumed on a large scale by ca 260, such production gave way by the end of the century to mintage within the North-west provinces. Coin production in London ca 294-324 was later supplemented by mintage at Trier and Lyons (Curnow and Reece, 1969). After 326, the three most important mints providing coins for Britain were at Trier, Lyons, and Arles, and after 356 the latter two supplied 60-80 per cent of the total coinage of Britain (Fulford, 1977b, 68). As with earlier coins produced in Rome, those minted at Lyons and Arles may have been shipped to Britain via the Rhone-Seine axis.

The two factors limiting the estimates of the quantity of coins entering Britain in the early Roman period do not seem to apply to the later Roman period. It is argued (Breeze, 1984, 274) that by the late Empire the military ceased subtracting the cost of essential items (discussed above) from soldiers' stipendia, and began paying soldiers their full stipendia in cash. In addition, the distribution of coinage throughout the North-west provinces suggests that by the late Empire, Britain was no longer a 'closed' monetary system, and that coinage was exchanged between provinces by both the state and private merchants (Walker, 1988, 305). However, coins entering Britain in the later Roman

period nevertheless would have remained in circulation for long periods of time. Moreover, numismatic evidence attests to a peak in currency circulation within Britain in the later Roman period (Walker, 1988). Therefore, in the later, as well as the earlier Roman period, soldiers' pay would have been met from coinage already circulating or produced within Britain, with occasional shipments of aes or denarii transported from Continental mints to 'top-up' the numbers of coins within the Romano-British monetary system.

French Atlantic Coast

Loire mouth. Given the proximity of the Central Gaulish kilns at Lezoux to the River Loire (see figure 71), it is possible that samian was transported downriver to the Loire mouth on the French Atlantic sea-board (Fulford, 1977b, 46). This route also may have been important for the distribution of Mediterranean goods. Indeed, Strabo's second route (Geog., 189) via the Rhone, Roanne and Loire is the second cheapest after the Bordeaux route (Peacock, 1978, 49).

Bordeaux. Bordeaux on the French Atlantic coast also seems to have received goods transported down the river systems from southern Gaul and even the Mediterranean. Indeed, it seems Bordeaux received La Graufesenque samian from southern Gaul destined for the North-east from the Conquest to ca 110 (Dickinson and Hartley, 1971, 131).

By the end of the 2nd century, the source of Continental wine importation was most likely focussed in the Rhineland (discussed above) and perhaps Atlantic Gaul (Richmond, 1946, 10). Marcus Aurelius Lunaris, the dedicant of an altar at Bordeaux in 237 (discussed below), is thought to have been involved with the wine trade, possibly directly with York (Richmond, 1946). Indeed, the staple trade of Aquitaine was wine (Columella de Agric, 3.2.19), and silver fir in the casks at Silchester can be found in the region of Bordeaux (Richmond, 1946, 9).

As for Mediterranean supplies, according to Duncan-Jones' transport cost index, Strabo's first route from the Mediterranean to the Atlantic across Gaul (Geog, 189) along the Rivers Narbonne, Aude, and Garonne to the port at Bordeaux would have been the cheapest (Peacock, 1978, 49). It is possible that supplies from the Mediterranean destined for the North-east were shipped along this route throughout the Roman period.

Spanish Coast

Gades (Cadiz), on Spain's south-west coast, would have received goods destined for the North-east from the interior of Spain. From the Conquest, Baetican (Dressel 20) amphorae, filled mainly with olives and olive oil (Callender, 1949, 117; Funari, 1991, 65; Williams and Peacock, 1983, 264) (used in cooking, illumination and personal hygiene), and although evidence is lacking, possibly fish sauce, wine and a host of

other goods,[1] were supplied to the North-east. Indeed, amphorae sherds and stamps found at Corbridge (Callender, 1949, 1965) and Vindolanda (Funari, 1991) attest to a domination of Baetican imports in the North-east throughout the 2nd century until the reign of the Severi, at which point most of the Baetican supply was diverted (Callender, 1949)[2] to other parts of the Empire, mainly Rome (ibid.).[3] The stamps found at Corbridge and Vindolanda refer to three cities - Corduba (Cordoba), Astigi (Ecija), and Hispalis (Sevilla) within the Guadalquivir Valley - which seem to have been central clearing-houses for amphora-borne produce, all of which are positioned on the same road which terminated at Gades on the south-west coast (see Funari, 1991, 65, his figure 12.1).

As discussed below, Gades would have been an entrepôt of Mediterranean supplies both before and after the cessation of Baetican shipments to Britain. Although some artefacts such as amphorae and other sherds, and bronze vessels[4] have survived, it seems that most articles imported to the North-east from the Mediterranean were perishable. In addition to those mentioned above, such items include Mauretanian lion skins required

---

[1] These include fruits and dried fruits, nuts, pepper, beans, and honey (Callender, 1965, 37-41).
[2] Although the quantities were greatly reduced, some Baetican amphorae continued to be imported to Britain throughout the first half of the 3rd century (Williams and Peacock, 1983, 268).
[3] As Britain and Spain had supported Albinus in his dispute with Severus, after the battle of Lyons in 197, the Spanish estates were confiscated and most of their produce was directed from Britain to other parts of the Empire (Richmond, 1946).
[4] Equivalent styles found at Pompeii suggest an Italian origin for two large vessels found in Pit II at Newstead: one is of green patinated bronze, highly-decorated, and with one handle (Curle, 1911, 273-4).

by musicians and standard bearers (Breeze, 1984), which may have been shipped to the North-east via North Africa and Gades. Evidence also suggests regular trade to Britain of sophisticated textiles such as Syrian silk (Wild, 1978, 79), and some of these, as well as less sophisticated Mediterranean textiles may have been supplied to the North-east.

In addition, most forts in the North-east would have had their own doctor and hospital, requiring medicines, ointments, special foods, and cough medicines (Davies, 1970a, 1970b). Originally, such requirements would have been sent from the cities of the Mediterranean, possibly in bulk form (ibid., 1970a, 92-3). Finally, if some of the more exotic foods consumed at London, Colchester and York, such as figs, grapes, lentils, dates, and prunes, also were available to soldiers in the North-east, these items would have been imported from ports in Italy, Spain, and southern Gaul (Kenward and Williams, 1979; Willcox, 1977; Breeze, 1984), perhaps via Gibraltar.

South Britain

In addition to receiving supplies destined for the North-east from Continental and Mediterranean ports (discussed below), South British ports also received supplies produced in South Britain for shipment to the North-east. Evidence suggests that many of these supplies were produced in areas within easy reach of a sea-port. Again, the type of material supplied depends upon the time period.

Early period. Although grain demands may have been satisfied for some of the Roman period from cultivation within the North-east (see Appendix H-3), it seems certain that in the first stages of the Roman period, and possibly also from the 3rd century, much of the grain supply would have been imported to a North-east port. It has been traditionally-held that such supplies came from Lowland Britain (Wheeler, M, 1954, 27; Piggott, 1958; Rivet, 1969a, 189). That South Britain was capable of supplying the North-east with sea-borne grain in the later period is suggested by Ammianus' account (18.2,3; discussed in Appendix G-3) of the interruption of shipments of British grain to the mouth of the Rhine in the mid-4th century after 'barbarians' had gained control of the lower Rhine.[1] In addition, evidence suggests that from the 2nd century (Salway, 1970, 12) East Anglian, Cambridgeshire, and Lincolnshire Fens were being drained[2] and that sea-banks were being constructed for the reclamation of wetlands along the Severn (Allen and Fulford, 1986).

Furthermore, in addition to bread wheat possibly from a Dutch port, analysis of carbonized grains from 3rd century granaries at South Shields has revealed similar quantities of spelt (van der Veen, 1988). All of the weedy species within the sample have been found associated with spelt wheat on late Iron Age or Romano-British settlements in Britain. Of these, Sieglingia are common in Britain but rarely recorded in the

---

[1] However, these grain shipments may very well have been an isolated event (Frere, 1987, 339).
[2] For a full discussion of the drainage of the Lincolnshire Fens by the Car Dyke, see Simmons, 1975 and 1979.

Netherlands or Germany (ibid.).

Oysters found at Benwell were perhaps cultivated in South Britain (Petch, 1928, 74; Spain, 1930, 130). If indeed,[1] it is possible that they originated from Rutupiae (Richborough), noted by Juvenal (Sat. 4.140). A Vindolanda writing tablet (Doc.39; Inv. 129; Layer 6) also attests to a soldier who had been sent fifty oysters from Cordonovi, an unknown place-name (Bowman and Thomas, 1983, 136), but most likely located outside the North-east.

2nd century. BB1 cooking ware was supplied to forts across the North-east from ca 120 to the late 4th century (Gillam, 1973, 61), from the south-western part of the province. On the basis of the large amount of ceramic wasters found at Poole and its environs, it seems certain that this was an important centre of supply (Farrar, 1973, 91-3; see figure 75).

BB2 cooking ware and Colchester mortaria were both supplied to the North-east by the mid-Antonine period and the re-occupation of Hadrian's Wall. BB2 was produced in the south-eastern coastal region, perhaps the Colchester area or Thames estuary (Farrar, 1973, 97), and continued to be imported until the mid-3rd century (Fulford, 1989, 185).

---

[1] Oysters can be transferred to new habitats (Bowman and Thomas, 1983, 137), and it is possible that these oysters may have been raised along the North-east coast.

Some of the early iron requirements of the North-east may have been fulfilled by iron-working in the Weald, Kent, where an estimated 700-750 tonnes of ore were extracted annually during the most intensive period 100-250 (Cleere and Crossley, 1985). In addition, tiles have been recovered in the Weald stamped Classis Britannica, suggesting that the fleet was involved with iron shipments, possibly to the North-east. The position of Kent on the south-east coast, together with an inscription (RIB 1340) recording construction at Benwell by the fleet, suggest an eastern sea-route of Wealden ore to the North-east.

Although the exact location is unknown, crystalline salt was extracted from brine on a large-scale at Red Hill on the Essex Coast during the Late Iron Age - Romano-British period (Rodwell, 1979, 157). In the middle of the 1st century AD, production moved to a more sophisticated operation in the Thames Mouth area (ibid., 160). This production was organized in smaller, more compact units than its East Coast predecessor, and may have been maintained under imperial control (ibid., 164). Supplies of salt from this area may have eclipsed Rhenish salt supplies to the North-east.

It seems that from the 2nd century, British production of glass may have superseded supplies of Continental glass (Price, 1978, 74) to the North-east. However, locating such Romano-British factories is made difficult by the fact that sites were small so that structural remains as well as waste products elude identification (Price, 1978, 70). Nevertheless, some production seems to have been carried out near the

sea. Two-handled oblong bottles found at Leicester, Colchester and Caerleon are thought to have been produced at Colonia Claudia Victricensis (modern Colchester; Price, 1978, 70), while archaeological evidence (such as the substructure of the furnace) for glass-making factories in Britain exists at Caistor-by-Norwich (ibid.).

6.1.2 Merchant Shipping

Once supplies destined for the North-east had arrived at a port, they would have been shipped either directly or indirectly to a port near the North-east. Before discussing the routes taken, mention should be made of how the supplies were transported to the various ports.

Merchants

Ceramic variation between northern Romano-British forts, and considerable variety within each site suggests that sea-borne distribution of Continental as well as South British goods was carried out by private businessmen (Gillam and Greene, 1981, 6-7):

> "Had army contracts and the self-interest of the state been more significant, the fluctuations in samian supply and the ad hoc nature of military pottery manufacture would surely have been less marked, and the many signs of competition, imitation, cost-cutting, and quality control amongst samian potters unlikely in a market system which was not determined by prices. It is now well established that there were pronounced fluctuations of samian supplies; furthermore, when samian imports into Britain were high, so were imports of other kinds of pottery."

That private merchants traded between the Continent and Britain is also attested by epigraphic evidence for altars dedicated by negotiatores cretarii Britanniciani, or traders in fine pottery with Britain[1] found at Colijnsplaat, the Rhineland, eastern Gaul and southern Germany (Hassall, 1978, 44). Shippers based at the different ports may have belonged to collegia, as indicated at Fectio (Vechten) by an inscription set up by the cives Tungri et nautae qui Fectione consistunt (CIL 13.8815).[2]

In addition to negotiatores, which may have been responsible for all of the cargo aboard a ship, mercatores seem to have been concerned with only a fraction of the cargo (Rouge, 1966, 290). Both types of merchants would have chartered ships from an agent - nauclerus and magister navis - of the shipowner - navicularius (Peacock and Williams, 1986, 64).

---

[1] Such pottery would have included samian and Rhenish wares as well as figurines (Tyers, 1978, 97).

[2] Hassall (1978, 45) suggests that negotiatores may have belonged to corpora (associations), whether collegia (guilds), whose members had a common interest, or societates (business partnerships). As for collegia, at Wiesbaden, negotiatores civitatis Mattiacorum were banded together into a guild which had its own schola (clubhouse) (CIL 13.7587). Similar guilds, either general or for a particular trade or craft, almost certainly existed in all the major Rhineland towns. As for societates, negotiatores also formed very small business associations (Hassall, 1978, 45). One such partnership is attested epigraphically: L Secundius Similis and T Carinius Gratus made a joint dedication at the shrine near Colijnsplaat. Evidence also suggests three generations of the same family all making dedications at Colijnsplaat (Bogaers, 1971b, 32).

Cargo

It is likely that many different cargoes were transported within the ships' holds. With the proliferation of private merchants, the shipping industry would have been motivated by profit, and certain items would have been more profitable to transport than others. Although valuable items such as wine, oil, textiles and raw materials would have been given priority, merchants would have taken on as many different items as possible, as increased exchange would have increased profits, and because increased weight would have given better ballast in rough seas.

Evidence for such diversification of cargoes is found aboard the Guernsey boat (discussed below), which was carrying African amphorae, sponge decorated bowls and three wine flagons from western France, a Rheinish beaker, and BB2 (Monaghan, 1987). As mentioned, analyses of Mediterranean wrecks suggest that non-perishable 'traceable' artefacts were accompanied by a much greater proportion of perishables carried in amphorae or raw materials such as metal ingots (Pucci, 1983, 111).

The exception to such diversification may have been shipments of iron and grain. As will be discussed, Wealden iron seems to have been transported by sailors of the Classis Britannica, while shipments of grain - the most important commodity to the army - also may have been carried out by the state, in which case profits may not have been the motivating force. However, if transported by a negotiator, other more profitable goods could have been sent 'piggy-back' with grain shipments.

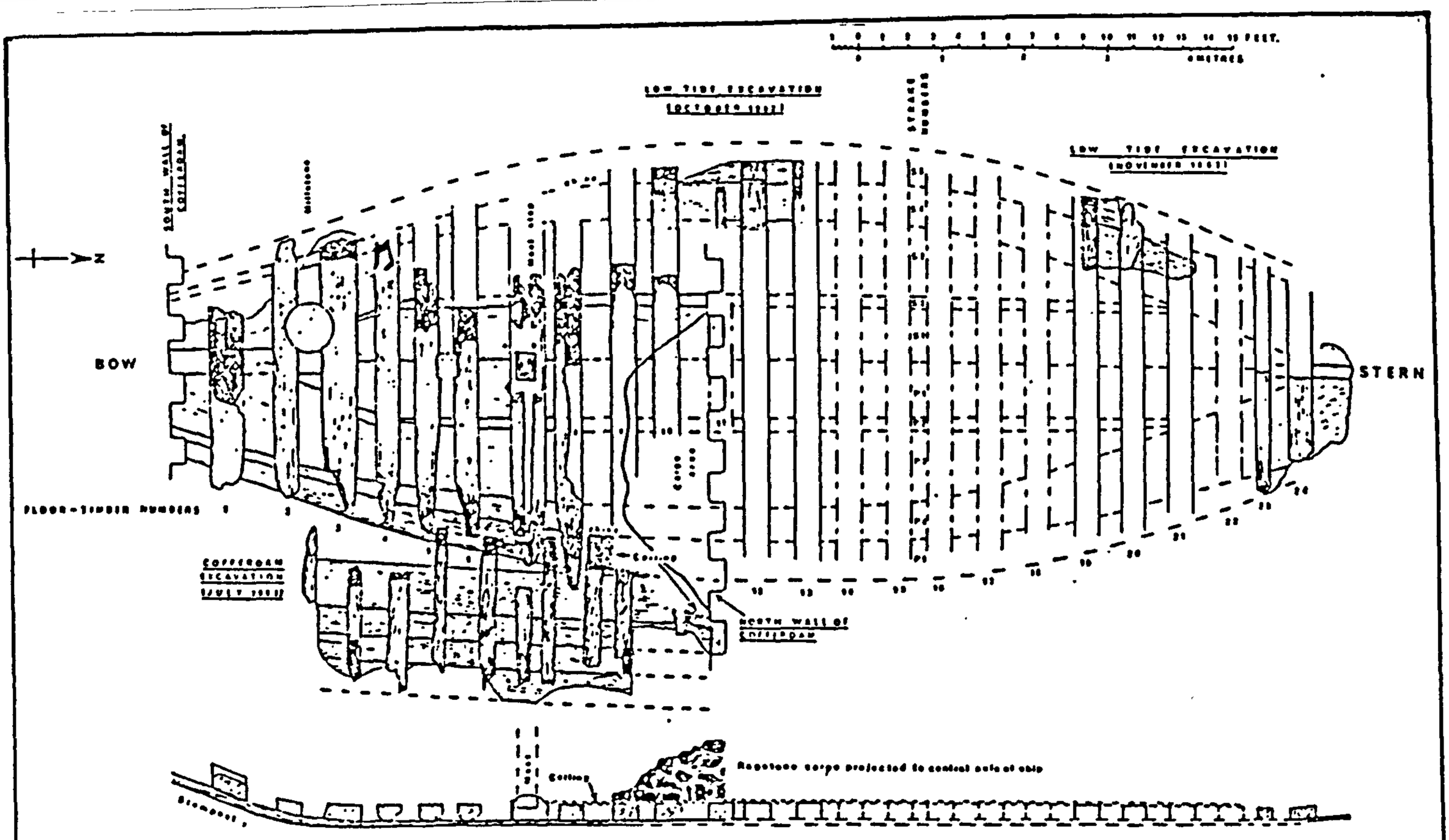


Fig 72: Blackfriars Ship, from Liversidge, 1968

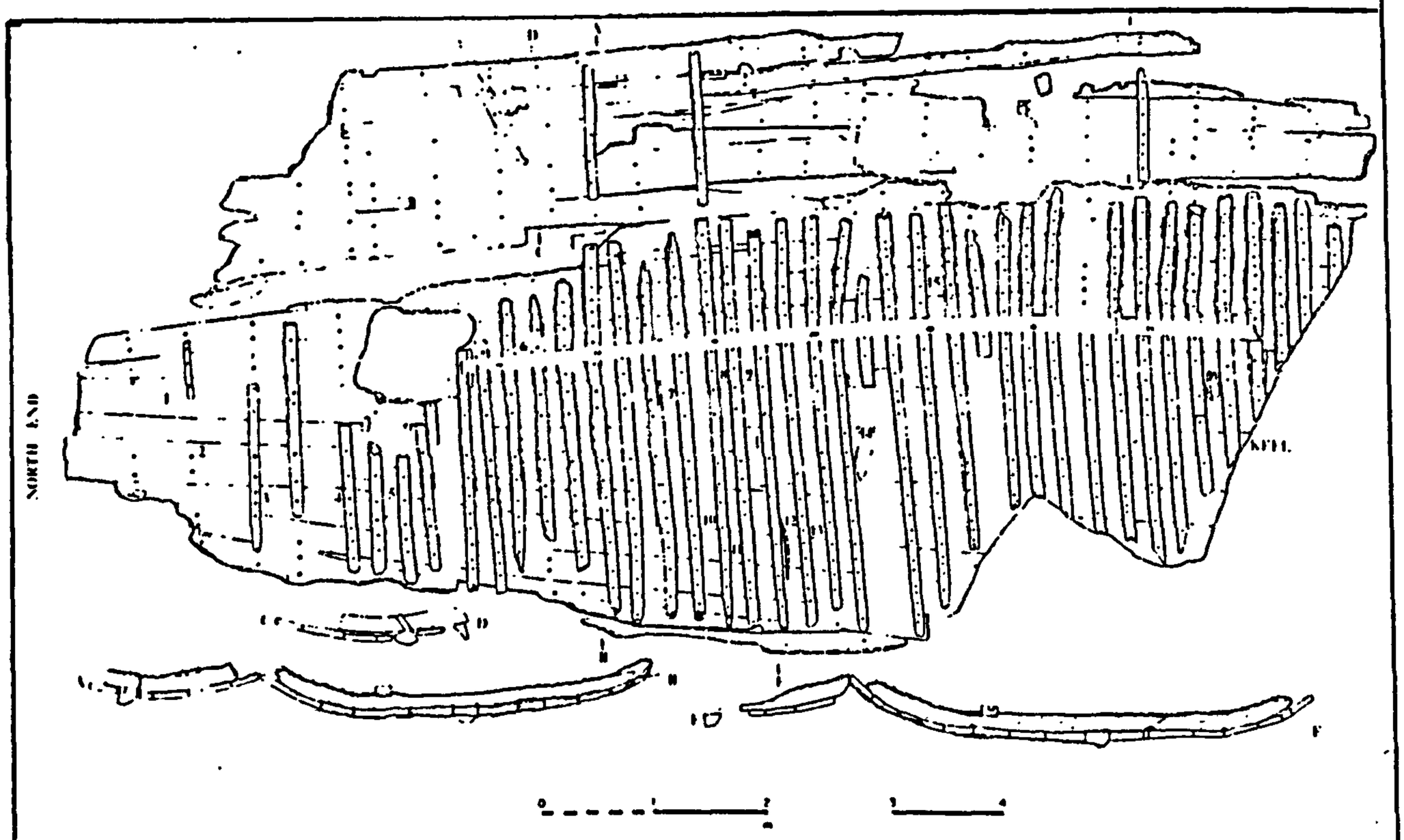


Figure 1. Plan of the County Hall ship. 1, Coin of Carausius; 2, paste bead; 3, coin of Tetricus under rib; 4, piece of pottery under rib to cover hole in plank; 5, clay packing to stop leak, covered with oak board 0 025 m thick; 6, pulley block under keelson; 7, ram's horn; 8, piece of pottery; 9, part of brooch in timber hole; 10, piece of pottery; 11, coin of Allectus; 12, belaying pin (?); 13, large iron nail; 14, detached rib; 15, large flint embedded in planking.

Fig 73: County Hall Ship, from Marsden, 1974

Ships

A distinction has been made between two very different styles of craft used in the waters off western Europe - Celtic and Mediterranean (Ellmers, 1969). Briefly, Celtic boats have a flat bottom and chine instead of the round hulls of Mediterranean ships, they employ caulking and nails hammered through strakes in side members or frames instead of mortise-and-tenon joints, have thwartships mast-steps and massive floor timbers often in pairs or threes, and are clinker rather than carvel built.

Celtic craft. Celtic boats seem to have been used along the coasts of Britain and the Continent before and throughout the Roman period. Indeed, Caesar describes the craft of the Veneti as follows:

"They build their hulls with flatter bottoms than our own craft to make it easier to go through the shallow depths of low tide and over the shoals; they build prow and stern as well up high to handle the size of the waves when a sea is running; and they use oak throughout to withstand any amount of violence and hard treatment. Beams are timbers 30cm sq made fast by iron nails 2.5cm thick, and anchors are held by iron chain instead of rope. Their sails are of hide or softened leather instead of canvas...because they reckon that canvas will not stand up to the violence of ocean storms and the force of the winds and will not drive such heavy vessels efficiently."

Caesar B Gall 3.13

Archaeological evidence for Celtic craft in Britain is as follows. The Blackfriars boat, found in 1962, is heavily cross-beamed, large at 15.25m long and 6.71m wide, flat-bottomed, keel-less, iron-fastened, made

of oak, and dated to the 2nd century AD (Johnstone, 1980, 89).[1] This sailing barge sank in the Thames while carrying to London a cargo of building stone, perhaps quarried in the Maidstone area, Kent (Marsden, 1967, 47).

Similar to the Blackfriars in many ways is the New Guy's House boat found in the Thames in 1958. It is about the same length, narrower at 4.27m, heavily-built, iron-fastened, oaken, and dates from about the end of the 2nd century (Marsden, 1965).

Excavated in 1984 and 1985 in St Peter Port Harbour, the Guernsey boat is the largest Roman period vessel found in Britain at 22-25m long (Monaghan, 1987). Again, the boat is oaken, iron-fastened, clinker-built, flat-bottomed and single-masted. As mentioned, it had been carrying a variety of cargo, the bulkiest of which was pitch, ca 530kg of which was recovered (ibid.). Numismatic evidence shows that the boat sunk (after a fire) ca 280-286 (ibid.).

The flat-bottoms of these 'Celtic' boats would have enabled them to put into river mouths and perhaps navigate certain distances upriver. As mentioned above (4.1.2), captains may have simply waited until an ebbing tide had deposited their coasters on the sand of the river mouth before attempting to load and/or unload (Monaghan, 1987).

---

[1] Sherds found in the layer of gravel trapped between the collapsed side of the vessel and its bottom have determined this date.

Mediterranean craft. An example of a 'Mediterranean' style vessel in Roman Britain is the County Hall ship. Found near the east end of Westminster bridge in the River Thames in 1910, coin evidence dates this boat to the late 3rd century - 290 at the latest. It is carvel built of oak, 18.3m long, 4.9m wide, masted, round-bottomed, built with a projected keel, and able to carry ca 60 tons (Marsden, 1972, 116-18; 1974, 65; see figure 73). The shape of its hull would have enabled it to navigate the open sea, while limiting its efficiency in shallow waters: it could have negotiated only the largest rivers (Marsden, 1974, 65). Of the rivers associated with the four ports serving the North-east - the Ouse at York, Solway on the west coast, Tweed at Berwick, and Tyne at South Shields - only the Ouse could have been navigated above its mouth for any considerable distance by the County Hall ship (discussed below, 6.3.1).

The recovery of the County Hall Ship suggests that boats sailed from the Mediterranean through Gibraltar and along the European west coast and the coasts of Britain. If so, the County Hall Ship's load carrying-capacity of 60 tons may represent the lower end of the scale of Mediterranean style ships sailing beyond Gibraltar. On the basis of wrecks and ancient sources, Fulford (1978, 67) argues that vessels carrying 200 tons were common throughout the Mediterranean in the Late Empire, and that ships of this size also may have plied the Atlantic and North Sea: indeed, smaller ships would have been more vulnerable than larger ships in high seas.

Therefore, it could well be that large Mediterranean ships sailed alongside Celtic ships from port to port along the Continental and British sea-boards throughout the Roman period.

Sea Routes to Ports near the North-east

It is likely that ancient merchantships called in at many ports along a given route. Not only could greater profits be made with increased exchange, shipping in the ancient world could often be risky and dangerous,[1] and especially in poor weather, prudence would have dictated less rather than more time spent on the open seas.

Alternatively, ships may have sailed from port to port buying and selling cargo with no fixed destination in mind. A good example of such trade is that of Argonne ware: on the basis of its recovery over a large area comprising west Germany, south Holland, Belgium and northern France, it may be that "export may have taken place from anywhere along the relevant coast-line ... as casual loads on a wide variety of routes" (Fulford, 1977b, 42). In other words, supplies may have been shipped to the North-east by merchantships sailing a pre-determined 'direct' route with many stops along the way, or along an 'indirect' route to the North-east comprising a circuit of various ports.

---

[1] By the Late Empire, navicularii on the Mediterranean (generally much calmer than the North Sea or Atlantic) were obliged to accept cargoes only between April 1 and October 10, as winter navigation was considered too dangerous to be worthwhile (Jones, A H M, 1973, 828).

Dutch Coast. Ceramic evidence suggests a direct link between ports on the Dutch coast and a North-eastern port. East Gaulish samian stamps account for 16.5 per cent of the total stamps found along Hadrian's Wall of the 2nd and 3rd centuries (Dickinson and Hartley, 1971, 130). If in fact East Gaulish samian was shipped down the Rhine, such a distribution suggests a direct Rhine-South Shields sea-link:

> "[this] high proportion is clearly to be explained by the position of the site. Merchants shipping from the Rhineland to Britain would naturally tend to seek harbours on the east coast and clearly the Tyne and Humber both received direct shipments from the Rhine".
>
> Dickinson and Hartley, 1971, 130

A direct sea link between the Rhine and South Shields is also suggested by an inscription dredged from the Tyne. RIB 1322 suggests troop movements between the Rhine and the Tyne ca 155: whether the troops were sent from the Rhine to the Tyne (Haverfield, 1903) or vice versa, this inscription nevertheless suggests that ships sailed directly between the Rhine mouth and South Shields in the 2nd century.

In addition, of the four inscriptions mentioning negotiatores Britanniciani on altars (over 150 in total) at Colijnsplaat and Domburg, one dedication at Colijnsplaat was made by a negotiator Britannicianus who also dedicated one at York - L Viducius Placidus (Stuart and Bogaers, 1971, no 45; Hassall, 1978, 46). The slab, found in 1976, has been dated to 221. Placidus appears to be a tribesman of the Veliocasses of the

Rouen area of northern Gaul (Hassall and Tomlin, 1977, no 18).[1] On the basis of this link, it is possible that other Rheinish inscriptions of the Domburg, Cologne and Mainz (CIL 13.8793; CIL 8164a; CIL 7300) recorded by men who traded with Britain may indicate a direct trade route to north-eastern ports.

However, the distribution of ceramics in the later Roman period suggests a Rhine-Thames link in lieu of a Rhine - North-east link. Over 90 per cent of 4th century German coarse wares from Speicher and Mayen in the Eiffel mountains have been recovered in the area of the Thames estuary, while ca 70 per cent of Argonne ware dated ca 260-425, presumably barged along the Meuse and Rhine, have been found along the Thames estuary (Fulford and Bird, 1975, 181; Fulford, 1977b, 42-5). Alternatively, only one sherd of Argonne ware has been found at York, and none in the North-east, while the recovery of German coarse wares in the north is equally as negligible (ibid, 43).

This evidence throws light on sea-borne trade from the Rhine to the North-east in the late Roman period. Reciprocal trade perhaps involving such items as 4th century Treveran coinage in the North-east and Yorkshire Whitby jet found along the Rhine (RCHME, 1962, 142) was most likely carried out vicariously through a Thames port.

---

[1] The dedication reads: "To Neptune and the Genius of the place and the Deities of the Emperors, Lucius Viducius Placidus, the son of Viducius, from the canton of the Veliocasses in the province of Lugdenensis, trader with Britain, presented the arch and gate in the consulship of Seleucus and Gratus [221]" (Hassall, 1978, 46).

French Channel Coast. Although no evidence attests to direct trade between ports along the French Channel coast and the North-east, such trade is nevertheless suggested by Boulogne's position by the 2nd century as headquarters of the Classis Britannica, a position which would have gained more significance with the eventual development of the Saxon shore defence system. However, by virtue of its position in the Channel, the port at Boulogne would have been linked more intimately with the ports of South Britain than those along the east coast, so that items received in the North-east from Boulogne are likely to have been shipped indirectly through South British ports.

French Atlantic Coast. A direct trading connection seems to have existed between Bordeaux and York in at least the 3rd century (Richmond, 1946, 10). This is suggested by the presence of a negotiator Britannicianus of Treveran extraction at Bordeaux (CIL 13, 634; Richmond, 1946, 9) named L Solimarius Secundinus, while an altar (mentioned above; AE 1922, no.116; Courteault, 1921, 101- 7; AE 1922, no 116) found in Bordeaux was dedicated by M Aurelius Lunaris, a sevir Augustalis of both York and Lincoln (Birley, E B, 1966, 228) in 227. The phrase ab Eboraci evectus, as well as the Pennine Millstone Grit into which the inscription was cut, suggests that shipping was carried out directly from York (Richmond, 1946, 9).[1] Another sevir Augustalis named M Verecundius Diogenes dedicated a sarcophagus in York (RIB 678: Birley, E B, 1966, 228).

---

[1] This altar probably travelled down the Ouse and out to sea without trans-shipment (Ramm, 1978, 45).

Diogenes was a tribesman of the Central Gaulish Bituriges Cubi, and possibly a moritex (E B Birley, 1966, 228; Celtic for shipper, Hassall, 1978, 42).

In lieu of the direct link, supplies from the French Atlantic coast would have been shipped via South Britain. Indeed, the distribution of La Graufesenque samian ware suggests that it was shipped first to London or Richborough before delivery to a North-east port (Dickinson and Hartley, 1971, 131).

Such a route is suggested later by the almost exclusive distribution of 4th century à l'éponge ware from the region of Aquitaine to Britain, predominantly the region around Clausentum (Fulford, 1977b, 46). That so few finds have been recovered in north-west France suggests the perpetuation of the French Atlantic coast-British link (ibid.).

Spanish coast. Until the end of the 2nd century, at least a certain amount of Baetican amphorae may have been exported directly by ship from Gades in Southern Spain to the North-east.[1] Gades, near the mouth of the navigable River Baetis west of Gibraltar, and at the terminus of a Roman road running through Baetica, was a major port during the Roman period, and ships are reputed to have made the journey from Gades to Ostia in seven days in favourable weather (Pliny the Elder, HN, 19.4).

---

[1] For the exportation of Baetican amphorae to the North-west provinces via the Rhône and Rhine, see Peacock and Williams, 1986, 136.

The trade route from Gades north along the Atlantic coast to Britain was known to the Phonecians of Gades who had apparently traded with Britons for Cornish tin (Charlesworth, 1926, 208). That Roman period merchantmen sailed directly to a North-east port from Gades is suggested by much epigraphic[1] evidence across the Empire attesting to Spanish merchants sending representatives abroad to conduct trade (see Callender, 1965, 48): although uncertain, some of these representatives may well have become established in the North-east. A direct sea route is also suggested by Spanish amphorae found north of the military zone and well away from Roman roads and forts in Britain.[2] These find spots suggest strongly that the vessels were transported by sea along the east coast (Callender, 1965, 56).

Gades would have received not only Baetican commodities, but also the various wares of the Mediterranean. Indeed, given the motivating factor of profits and ballast, it is unlikely that merchants sailing from the Mediterranean to Gades would have arrived with empty holds. Rather, in order to make room for the Baetican imports for a return journey, the Mediterranean commodities would have been off-loaded at Gades. Some of these items may have been shipped along the Atlantic coast for eventual

---

[1] The evidence is found in the similarity of stamps connected with Aurelius Heracla and Son, the occurrence of F Scimniano and L Iunius Melissus on the same amphorae, and the frequency with which abbreviations such as Sals, Riv, Sae and Med are repeated on different stamps (Callender, 1949, 116).

[2] Spanish vessels have been found in Constantine's Cave in East Fife near to Fife Ness, on the southern shore of the Firth of Forth at Seacliff in East Lothian, at Broch of Bow, Midlothian, and at Grange of Conana, Angus (Callender, 1965, 56).

delivery to the North-east. Before the 3rd century, such items as medicines, animal skins, precious metals, luxury foods, and textiles could have been shipped together with Baetican exports in the same vessel.

The shipment of these items via Gades to the North-east need not have stopped with the cessation of Baetican exports to Britain. As Baetican commodities continued to be shipped across the Mediterranean after the Severan-Albinus episode, ships would have continued to arrive in Gades laden with Mediterranean commodities. African Red Slip ware of the 3rd-5th centuries found at York (Bird, 1977) perhaps acts as a proxy for shipments of such material from the Mediterranean via Gibraltar and Gades. Indeed, the Mediterranean County Hall Ship, which sunk near the end of the 3rd century, may have carried such cargo to Britain.

On the other hand, it is possible that the cessation of Baetican amphorae supply to Britain marks a period of decreased shipping from the south of Spain along the west coast of Europe to Britain. Millett (1990, 163) argues that such military supply networks may have become severely disrupted by the anarchy of the 3rd century and by Britain's isolation from the Mediterranean during the Gallic Empire and the usurpation of Carausius and Allectus (260-73 and 286-96).

Fig 74: BB ware in the Frontier Area, from Gillam and Greene, 1981.

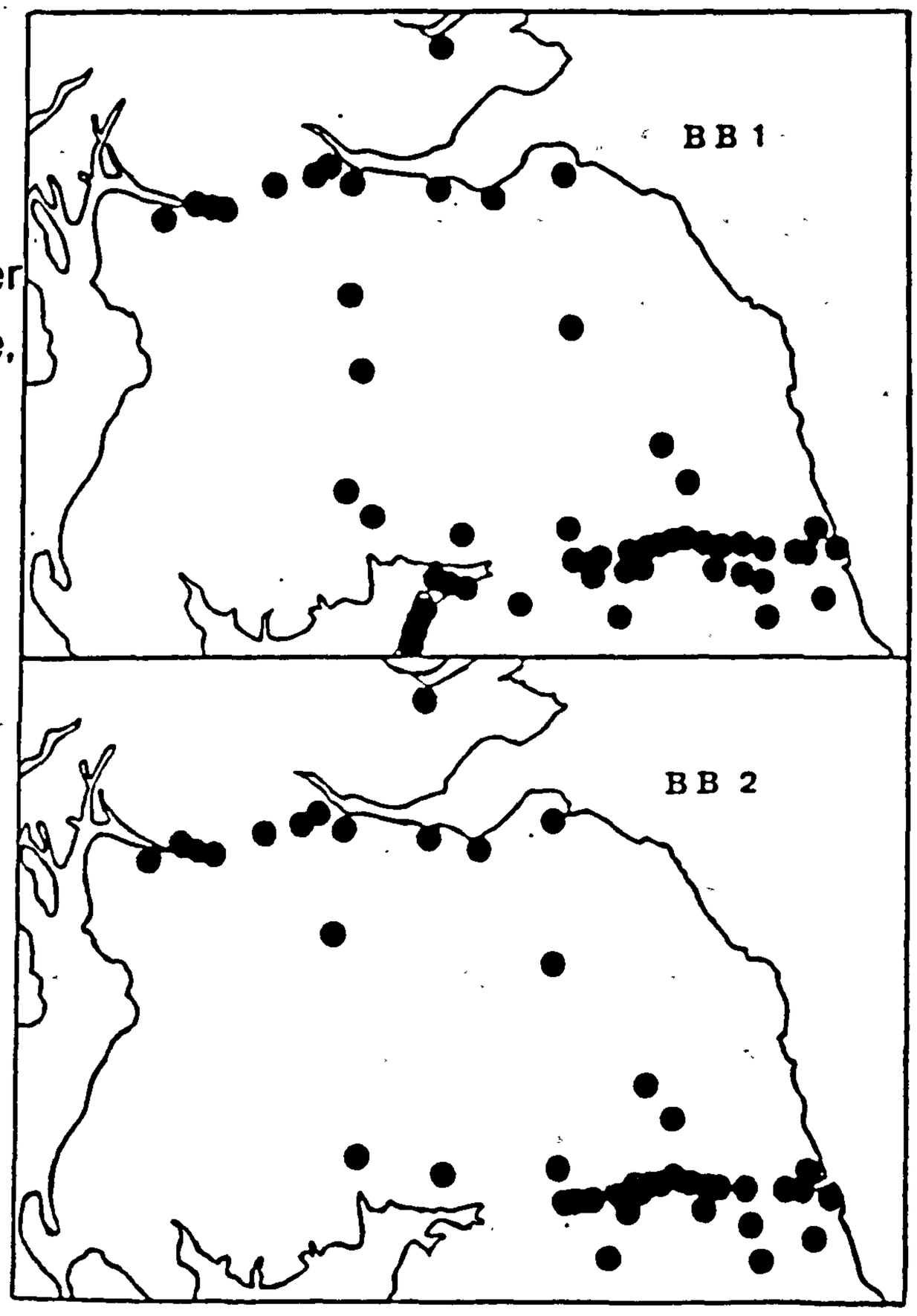
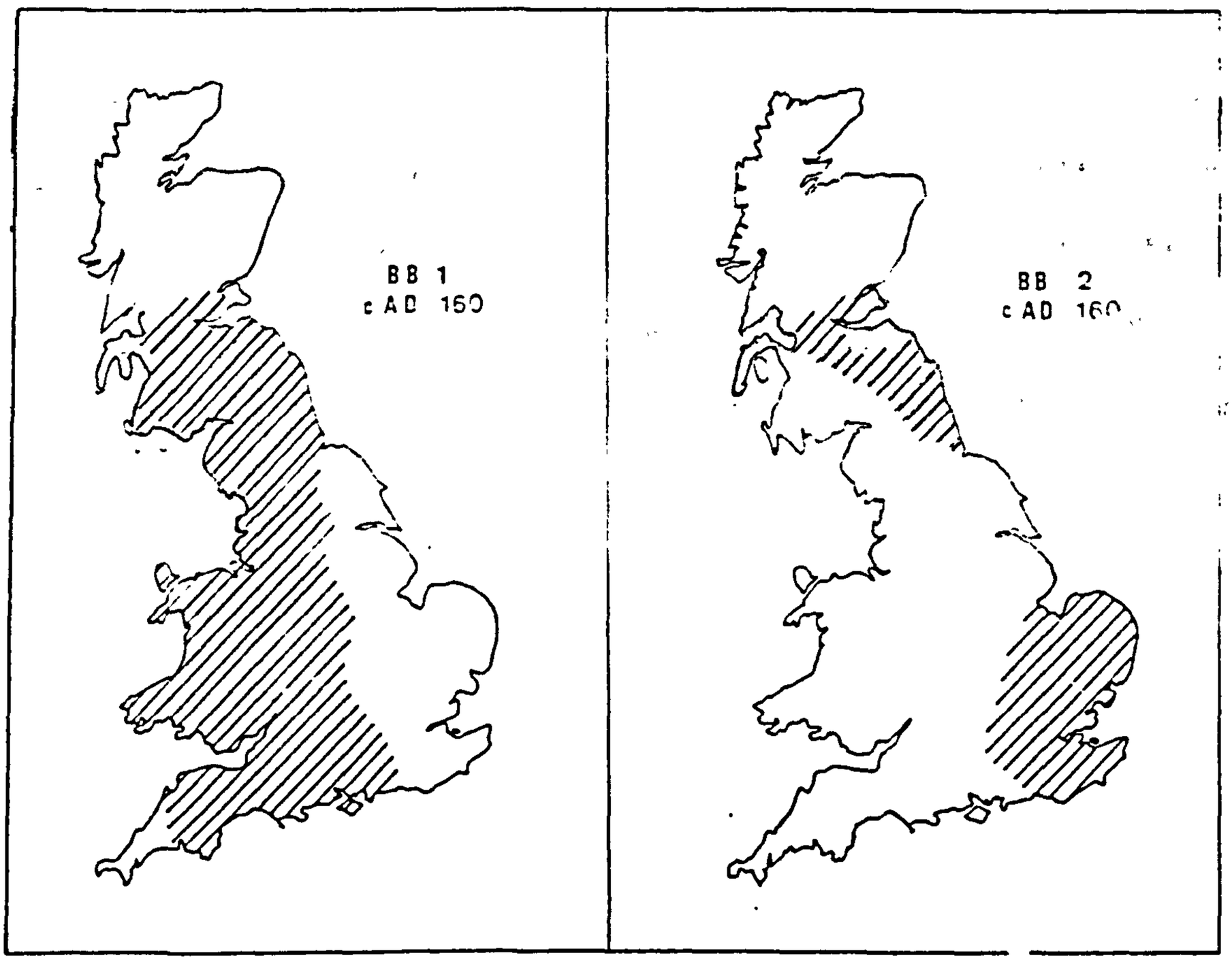


Fig 75: BB ware across Britain, ibid.



South Britain. The most important indicator of sea-borne trade routes to the North-east from South Britain is the evidence from pottery distribution, and especially BB ware. Indeed, as pottery requirements in the North-east at any given time would have amounted to no more than a small fraction of the cargo-carrying capacity of Roman period coasters, and as cooking-ware is relatively bulky, heavy, and less valuable than other items, BB ware would have been shipped in addition to items more expensive and which have remained archaeologically invisible.[1]

Alternatively, this pottery may have been shipped with grain for reasons other than profit: Greene (1979, 103) argues that BB1 may have been successful on Hadrian's Wall because a negotiator was shipping grain and textiles from south-western England to the same area, and that pottery made good ballast for the uncertain western sea routes. The evidence of BB1 and BB2 suggests that throughout the 2nd and 3rd (and 4th for BB1) centuries, pottery and other items were shipped to ports near the North-east from ports along the south coast of Britain.

BB1 was most likely shipped to a port in the Solway Firth ca 120, or at the commencement of the construction of Hadrian's Wall, from a production source near Poole. By 140, BB2 was supplied to the army on the new 'frontier', the Antonine Wall. Although outnumbering BB1 in Scotland 5:3, BB2 was absent from the early-Antonine levels of forts in the North-east such as Corbridge and South Shields, even though BB1 was

---

[1] The role of pottery as a 'tracer' for the much larger shipment of supplies along the Rhine frontier is argued by Middleton (1979).

still being supplied. Because of the alacrity of its rise to predominance in Scotland during the Antonine Wall period, BB2 must have been shipped to the Forth as soon as possible:

> "It is as though ships from the Thames estuary unloaded none of their cargo in the Tyne on their way to the Forth. The black-burnished requirements of the Tyne-Solway isthmus were met by BB1 which was probably imported by way of the Solway."
>
> Gillam, 1973, 57

Therefore, it seems that BB1 continued to be supplied to forts in the North-east from a port on the west coast throughout the Antonine Wall period.

After the abandonment of the Antonine Wall, BB2 began to be supplied to forts in the North-east. Quantities of BB2 have been recovered at South Shields, Carrawburgh, Chester-le-Street, Corbridge, Ebchester, and Benwell. In turrets within 16km of Newcastle, and in the central sector, BB2 represents 41 per cent and 25 per cent of all the ceramics, respectively (Gillam and Greene, 1981, 16-18). The distribution suggests that South Shields was the port to which BB2 was shipped for the supply of forts in the North-east (Gillam, 1973). As only two finds of BB2 have been recovered on the western half of the Wall compared to a continued representation of BB1, it seems that the western part of Hadrian's Wall continued to be supplied from a west coast port after the re-occupation of Hadrian's Wall (see figure 74; Gillam, 1973, 58; Fulford, 1977a, 304). In total, the BB evidence suggests that forts in the North-east were supplied via a west coast port during the first Hadrianic and Antonine Wall periods, after which South Shields became the dominant port.

The eventual cessation of BB2 and Colchester mortaria distribution, as well as the lack of Argonne or German coarse ware distribution in the North-east, suggests a decrease in shipping from South Britain to the North-east from the 3rd century. However, it is also possible that the cessation of such pottery importation was due to the emergence and rapid rise to dominance of Dales Ware by the 4th century (Gillam, 1973, 61; below, 6.2.2). That at least some east coast shipping continued is suggested by the necessity for shipments of South British grain to the North-east (see Appendix H-3.3), as well as the recovery of 4th century Oxfordshire ceramics at Traprain Law (Fulford, 1977b, 56).

6.1.3 Destination: Ports serving the North-east

York

Ceramic and epigraphic evidence for sea-borne trade links between York and South Britain or the Continent discussed above (6.1.2) attests to the vitality of the port below the legionary fortress at York.[1] During and at least shortly after construction of forts in the North-east, the port at York would have been the main source of supplies reaching the North-east from long distances away: legionaries of VI Legion Victrix stationed at York constructed, for the most part, forts and roads, as

---

[1] In addition, evidence attests to ships piloted by soldiers of the Sixth Legion at York. RIB 653 reads: "To the African, Italian, and Gallic Mother Goddesses Marcus Minucius Audens, soldier of the Sixth Legion Victrix and a pilot of the Sixth Legion, willingly, gladly, and deservedly fulfilled his vow" (Collingwood and Wright, 1965, 219).

well as much of the Wall in the North-east, and York remained throughout the Roman period the command centre of the North-east. As York continued to function as the main port for Continental and South British imports to the North-east until at least the mid-Antonine period and the rise of South Shields as a dominant port, the time-span of its function as a port serving this survey area covers ca AD 75-to at least AD 165.

Of the traceable artefacts, the bulkiest materials transported from York to the North-east would have been grain, nails, querns, Baetican amphorae (holding oil, wine, and fish sauce), barrels (holding wine, and possibly salt, fish sauce and other commodities), and soldiers' pay. However, as discussed in Appendix H-3.2, grain importation from the Rhine or South Britain may soon have been at least supplemented by local supply, while the supply of Rhe nish querns would have been of short duration. Indeed, as will be discussed (6.2.3), raw materials soon were gained from local quarries, mines, and forests. Although Baetican imports would have continued to be supplied from York, amphorae were manufactured specifically to facilitate transportation, and although heavy, could be packed into a relatively compact area.[1] The same can be said for barrels, which may have been shipped directly to York from ports on the Dutch or French Atlantic coast. As for soldiers' pay, York

---

[1] Indeed, amphorae were produced in sizes large enough to contain bulk quantities, but small enough to be handled by one person (Will, 1977), and in shapes which would allow them to be transported in a tight mass. In addition, compared to contemporary amphorae, Dressel 20 amphorae were very efficient containers, holding a very high ratio of material in relation to their size and weight (Peacock and Williams, 1986, 53).

- the command centre of the North-east - probably continued to receive pay chests for the North-east at least until the mid-Antonine period.

Other items transported to the port at York and supplied to the North-east until the mid-Antonine period would have comprised very little bulk. Mediterranean and Continental non-perishable supplies including fine table ware, glass, mirrors, salt, coinage, and perishable items, such as medicines, animal skins, precious metals, textiles, and luxury foods could have been shipped to York upon vessels such as grain ships from a Dutch port, Mediterranean merchantships carrying Baetican commodities from Spain, or on virtually any vessel sailing out of an Atlantic Continental or South British port.

West Coast

Forts in the North-east were supplied with BB1 and other cargo transported on ships leaving Poole Harbour, rounding Land's End and eventually putting-in to the Solway or the Clyde during the first Hadrianic and Antonine Wall periods, after which west coast supply to the North-east seems to cease.

It is uncertain whether one port served the North-east more than another. An altar (RIB 2059) at Bowness-on-Solway on the western end of Hadrian's Wall, dedicated by one Antonianus prior to setting out on a commercial venture in the north-west seas (Hassall, 1978, 42) attests to one port of call. In addition, Kirkbride, mentioned on a Vindolanda

writing tablet (above, 4.4.1), also may have received supply ships.[1] Alternatively, or perhaps additionally, Maryport may have been an important port (Jarrett, 1976), with a substantial settlement between the fort and the harbour. However, certain evidence suggests Carlisle may have been the most important port. First, if indeed the Solway was navigable to Carlisle, this was the closest point to which ships could have supplied the Wall garrisons, as well as those in south-west Scotland, and Stanwix, the nearby double strength garrison (Higham, 1976, 220). Second, Luguvalium, the civilian settlement at Carlisle and a civitas capital by the 3rd century, seems to have been occupied not only from the Trajanic period through to the 4th century, but also seems to have survived for a period after the Roman garrison had withdrawn from the fort (McCarthy, Padley, and Henig, 1982). The town had been carefully laid out, and the buildings as well as artefacts recovered attests to the considerable wealth of its citizens (Higham, 1986, 220), suggesting that it may have been an important market town at the interface between sea-borne and overland transportation.

Given the often treacherous waters off the west coast, as well as the scarcity of ports compared to the east coast, it is likely that ships sailing from the Continent to the Solway Firth first called in at a South British port. Therefore, the range of Continental goods may have been collected alongside South British wares in a South British port before shipment to the Solway. Given that West coast ports and York were

---

[1] If Kirkbride is indeed Briga.

receiving supplies destined for the North-east during the same time period, the supplies themselves, as well as the vessels used, may have been roughly the same.

Berwick-upon-Tweed

Berwick-upon-Tweed may have been a port receiving supplies for forts in Area 3 during the Flavian period. As discussed below (6.2.1; Appendix J-2.2), it is possible that the Devil's Causeway was constructed to Berwick, at the mouth of the Tweed, so that Agricola could not only penetrate the land of the Votadini, inhabiting what was to become the eastern flank of Dere Street, the main trunk route north, but also so that a connection might be made between the army and fleet off the North Sea coast. Indeed, Tacitus states that Agricola, while advancing in northern Scotland, relied heavily on the Classis Britannica for supplies and reconnaissance as well as transportation for his troops:

> "Agricola was the first to make it [the fleet] a factor in his campaigns...the war pushed by sea and land simultaneously, and often infantry, cavalry, and marines, sharing their rations in a joint celebration, magnified their several feats...[with] forest depths and mountain heights on one side, the trials of tempest and of seas on the other".
>
> Agric 25.1

No Roman period structures have been recovered in the area of Berwick-upon-Tweed. However, industrial activity from the mouth of the Tweed to Berwick from the Medieval to present day has been intense, so that if such Roman period structures existed, they have since been

destroyed or obscured. At the same time, such structures may not have been substantial. Indeed, Berwick-upon-Tweed may have been a port receiving military supplies only for a short period. As discussed (above, 5.3.1; Appendix J-2.2), since the only fort along the Devil's Causeway - Low Learchild - fell out of use possibly by the end of the Flavian period or shortly thereafter, so too would have the Devil's Causeway, and subsequently would have ceased to function as a supply medium for the port at Berwick-upon-Tweed. Therefore, original timber structures constructed at Berwick-upon-Tweed to receive sea-borne supplies for shipments down the Devil's Causeway may never have been rebuilt in stone, and so have completely perished.

Supplies, as well as vessels and routes by and over which supplies were transported to Berwick-upon-Tweed would have been roughly the same as those shipped to York.[1]

---

[1] That at least a certain amount of shipping continued to Berwick is suggested by the settlement at Tweedmouth, ca 1.6km south of the terminus of the Devil's Causeway and upon a hill overlooking the river mouth. Comprising two ditches on the east side and rounded east angles, with a north-south dimension of 75m (St Joseph, 1951, 56), this feature conforms to other Late Iron Age - Romano-British settlements in Northumberland (St Joseph, 1969, 107). During a small excavation in 1946, Sir Walter Aitchison recovered a sherd of late 3rd century mortarium (St Joseph, 1951, 56), suggesting at least a certain amount of continued sea-borne supply to Berwick.

South Shields

As discussed above (4.1.1), South Shields may have received a limited amount of sea-borne supplies from Flavian to Hadrianic times. If the Stanegate was constructed east of Corbridge to South Shields (discussed below, 6.2.1), Agricola may have used this port in the same way it has been suggested that Berwick-upon-Tweed could have been used, to maintain communication with, and secure supplies from the fleet. However, after the Conquest, the lack of forts east of Dere Street in Areas 1 and 2 suggests against sea-borne supply to South Shields before the Hadrianic period. With construction of the Wall, despite the ceramic evidence, a certain amount of supply may have been carried out via the port at South Shields to those forts east of Portgate on the Wall.

The rise of South Shields as a dominant port supplying forts in the North-east comes with the re-occupation of Hadrian's Wall in the mid-Antonine period, ca 160. Epigraphic evidence dated ca 155 attesting to a direct link with troops on the Rhine (RIB 1322; above), as well as two inscriptions (RIB 1319-20) dredged from the Tyne at Newcastle, dedicated by soldiers of the Sixth Legion at York to Neptunus and Oceanus, suggest a link between the Tyne and the sea (Collingwood and Wright, 1965). Evidence mentioned above of Central and East Gaulish samian also attests to a South Shields-Dutch coast link in this period, and BB2 evidence attests to ships supplying South Shields from South British ports from the time of the re-occupation of Hadrian's Wall. All of this evidence coincides with construction of the first stone fort at

South Shields in the Antonine period.

Overall, supplies shipped to South Shields from the mid-Antonine to the beginning of the 3rd century may not have represented much bulk. Unlike other ports serving the North-east, it seems that South Shields flourished as a port at a time when the local area had begun producing many of the army's requirements (discussed below). Thus the full requirement of the bulkiest of the supplies - grain - may not have been shipped to South Shields, while nails, querns, and certain raw materials already could have been gained locally. The bulkiest items shipped to the Tyne may have been Baetican amphorae, barrels, cooking ware, and, given the importance of South Shields as a port, perhaps soldiers' pay. The remainder of the non-perishable 'tracers' as well as the likely perishable commodities from the Mediterranean and Continent would have been the same as those supplied to York.

By the 3rd century, demands and therefore supplies shipped to South Shields had changed. Combined evidence (discussed in Appendix H-3.3) suggests a considerable amount of grain importation into South Shields, probably from the Continent and South Britain from the beginning of the 3rd century through to the end of the Roman period. Baetican imports cease, although other Mediterranean imports may have remained virtually the same. Ceramic evidence suggests that by the 4th century, the direct link between the Tyne and Rhine had ceased, while east coast trade in general seems to have decreased.

6.1.4 Discussion

Although the nature of the evidence limits the scope for interpretation, a general picture might be drawn of sea-borne supply to this survey area. Soldiers in the North-east may have required the bulk of Continental and Mediterranean supplies from the Conquest and throughout the 2nd century. Traceable commodities from the Mediterranean such as pottery, amphorae, coinage, and glass perhaps represent only a portion of the overall trade which included perishables either organic, such as textiles and foodstuffs, or inorganic, such as raw materials. As agriculture and industry of the North-west provinces developed, grain, pottery, wine, glass, and other commodities were shipped for use in the North-east. Such commodities were shipped from various ports along the Spanish, French and Dutch coasts. These ports received goods not only from their respective hinterlands, which in the case of the Continental ports reached as far inland as the Mediterranean, but also from ships plying from port to port buying and selling various commodities. From the ports, commodities were carried over certain routes upon either Celtic or Mediterranean ships owned and operated by private merchants. Supplies may have been ear-marked for direct delivery to a port near the North-east, or may have been delivered after the merchants had visited various ports along the way.

Many Continental or Mediterranean supplies destined for the North-east would have been shipped first to a South British port. These supplies, together with supplies produced in South Britain, were shipped along

either the east or west coasts to a port near the North-east. By the 2nd century, ceramic evidence suggests that South Britain was supplying the North-east with many of its requirements, although not necessarily grain. This gradual development eventually allowed a virtual self-sufficiency within Britain in some areas, so that Continental and Mediterranean imports (especially of pottery) to the North-east decreased. As will be discussed (6.2.3; Appendix H-3), in other areas of the economy such as grain production, the North-east had to rely on imports from outside Britain by the 3rd century.

Supplies destined for the North-east may have been sent to Berwick-upon-Tweed until the Trajanic period, and to York and the Solway Firth until the mid-Antonine period. Bulky supplies, with the exception of amphorae, barrels, and pay chests, would have been supplied to the North-east from York and the West Coast only for a short duration, after which many of the demands, notably grain, may have been met by local production. By the mid-Antonine period, South Shields had gained prominence as the major port in the North-east, and by the Severan period, had become the major entrepôt for renewed large-scale grain importation to the North-east.

By the later period, although ceramic evidence suggests a decrease in sea-borne supply along the east coast, the continuation of granaries at South Shields nevertheless suggests that a certain degree of east coast shipping from south Britain to the North-east continued throughout the Roman period. In addition, numismatic evidence from Trier, Arles, and

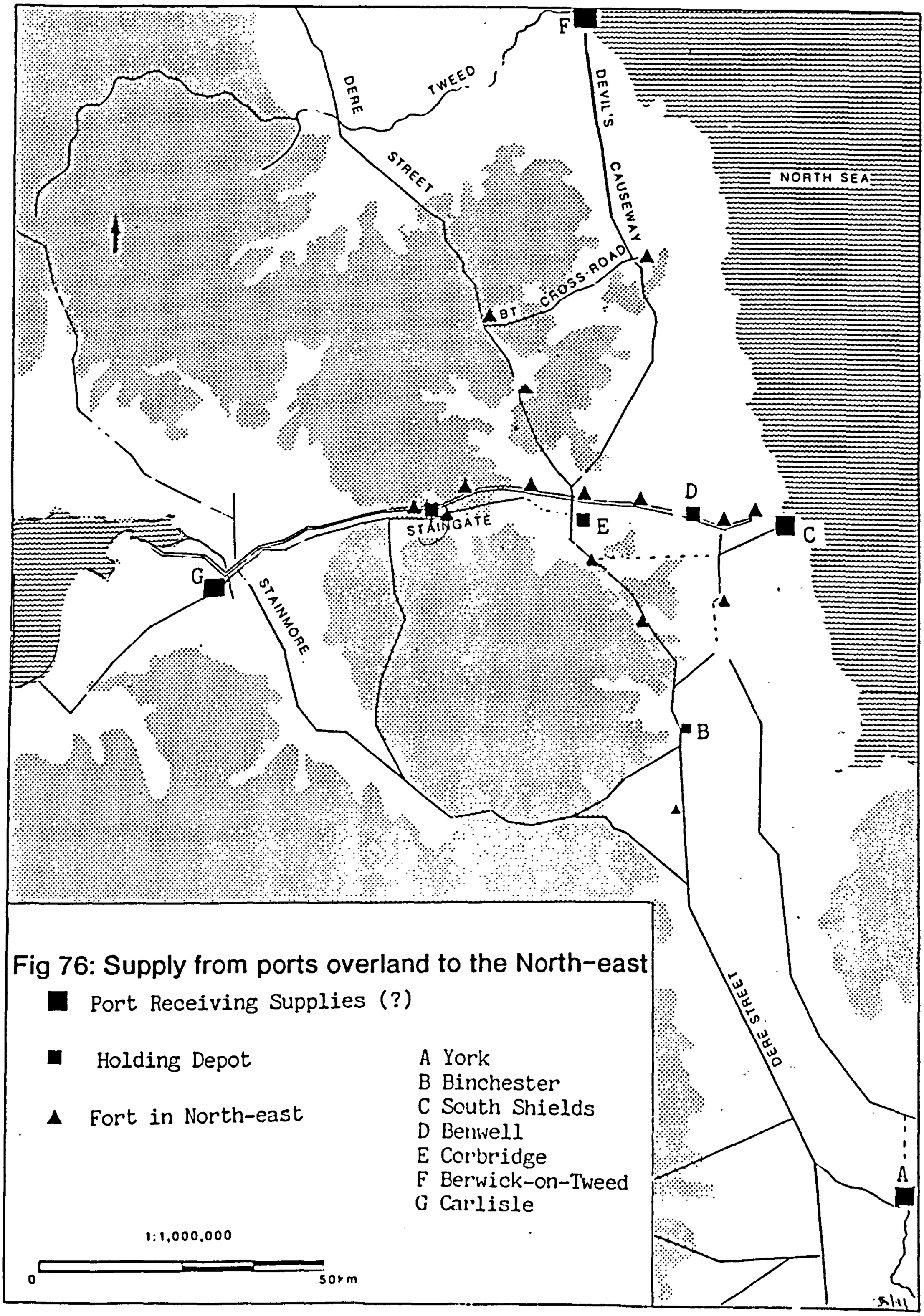


Fig 76: Supply from ports overland to the North-east

■ Port Receiving Supplies (?)

■ Holding Depot

▲ Fort in North-east

A York
B Binchester
C South Shields
D Benwell
E Corbridge
F Berwick-on-Tweed
G Carlisle

1:1,000,000

0 50km

Lyons suggests that although supply from the western provinces to Britain had begun to wane from the 2nd half of the 4th century, the transport of Mediterranean commodities through Gaul to Britain may have continued at least to the end of the Roman period (Fulford, 1977b).

6.2 ROAD TRANSPORT

The supply of forts in the North-east could have been carried out over long distances overland from ports near the North-east or from South Britain, or over short distances from the local area around the forts (see figure 76). Indeed, roads were constructed originally to provide a medium of transportation along which the army could advance, and over which supplies could be transported. Forts were constructed at key points (discussed below, 6.3) in the North-east to ensure the integrity of a certain stretch of road upon which each was constructed. With each passage under Roman control, transportation of supplies whether in a 'convoy' or on an individual basis could have been ensured. Indeed:

> "Amongst the things for which it is thought a general must make provision, whether based in camp or in a city, are that pasturage for the animals, the transport of grain and other things, watering, gathering of wood, and foraging are rendered safe from attack by the enemy. Because otherwise, if garrisons are not distributed at particular points, whether these should be cities or walled forts, our supply convoys cannot pass to and fro. If suitable places have not been fortified previously, they are strengthened; forts in such places are quickly surrounded with large ditches. For forts (castella) are named from the diminutive term for fortresses (castra). The many infantry and cavalry based in these are responsible for maintaining a safe route for convoys. For only with difficulty does an enemy dare to approach, now being hindered from in front and behind."
>
> Vegetius, Epitoma rei militari III 8

Table 2: Road Transport Distances in the North-east.

	Destination	Origin								
	Sites in Survey	Supply Depot						Holding Depot		
		York			South Shields			Corbridge			Binchester		
Area 1		Dist	Route	Days	Dist	Route	Days	Dist	Route	Days	Dist	Route	Days
	Piercebridge	128	DS	6	75	S DS	3	16	Ds	1	14	DS	1
					65	S-BR DS	3						
	Binchester	142	DS	6	61	S DS	3	46	DS	2			
					51	S-BR DS	3						
	Lanchester	162	DS	7	41	S DS	2	26	DS	2	20	DS	1
	Ebchester	172	DS	7	31	S DS	2	16	DS	1	30	DS	2
	Chester-le-Street	180	DS-BR	7	37	S BR	2	46	S-BR	2	24	DS BR	1
Area 2		York			South Shields			Corbridge			Binchester		
		Dist	Route	Days	Dist	Route	Days	Dist	Route	Days	Dist	Route	Days
	South Shields							47	S	2			
	Wallsend	193	DS S	8	19	W M	1	39	S M	2	9	M	1
								36	DS M	2			
	Newcastle	188	DS S	8	14	W	1	34	S	2	4	M	1
								31	Ds M	1			
	Benwell	192	DS S	8	18	W M	1	38	S	2			
	Rudchester	203	DS S	9	29	W M	2	11	S M	1	11	M	1
		214	DS M	9				16	DS M	1			
	Halton Chesters	193	DS M	8	52	S DS	3	5	DS M	1	32	M	2
					50	W M	2						
	Bywell	196(?)	DS(?)	8	55(?)	S(?)	3	8(?)	(?)	1			
	Corbridge	188	DS	8	47	S DS	2						
	Chesters	200	DS S	8	59	S	3	12	S	1			
		201	DS M	9	60	W M	3	13	DS M	1			
	Carrawburgh	202	DS S	9	61	S	3	14	S	1			
		205	DS M	9	64	W M	3	17	DS M	1			
	Vindolanda	211	S DS	9	70	S	3	23	S	1			
	Housesteads	210	S DS	9	69	S	3	22	S	1			
		213	M DS	9	72	W M	3	25	DS M	1			
	Great Chesters	216	S DS	9	75	S	3	23	S	2			
		222	M DS	9	81	W M	4	34	DS M	2			
	Haltwhistle Burn	215	S DS	9	74	S	3	27	S	2			
		223	M DS	9	82	W M	4	35	DS M	2			
Area 3		York			South Shields			Corbridge			Risingham			High Rochester		
		Dist	Route	Days	Dist	Route	Days	Dist	Route	Days	Dist	Route	Days	Dist	Route	Days
	Risingham	212	DS	9	71	S DS	3	24	DS	1				14	DS	1
					71	M DS	3									
	Blakehope	221	DS	9	80	S DS	4	33	DS	2	9	DS	1	5	DS	1
					80	M DS	4									
	High Rochester	226	DS	10	85	S DS	4	38	DS	2	14	DS	1			
					85	M DS	4									
	Brinkburn	267	DS-BR-DC	11	139	S DS B DC	6	79	DS BR DC	4	55	DS BR DC	3	41	DS BR DC	2
		226	DS DC	10	85	S DS DC	4	38	DS DC	2	58	DS DC	3	72	DS DC	3
	Low Learchild	254	DS BR	11	113	S DS BR DC	5	66	DS BR	3	42	DS BR	2	28	BR	2
		239	DS DC	10	98	DS DC	4	51	DS DC	3	71	DS DC	3	85	DC	4

Key: BR - Branch Road

DC - Devil's Causeway

DS - Dere Street

S - Stanegate

W - Wreckendike

Days= Amount of days needed for supply by oxen at 25km/day

J/91

As discussed above (2.2), both ox-carts and pack animals would have been used for transport of materials across the North-east. Material which was bulky, very heavy, and/or awkward would have been transported by ox-cart at a rate of 25km/day. Such supplies include grain,[1] soldier's pay, querns, nails, amphorae, cooking-ware, barrels, metal ores, timber, and building stone. Material comprising less bulk and which could have been divided into two equal panniers probably would have been sent by pack animals at a rate of 80km/day. Such material includes fine-ware pottery, textiles, glass, salt, animal skins, precious metals, luxury food, and medicines.

Apart from cooking-wares and most material in amphorae and barrels, the bulky items mentioned above were essential to the survival of the fort, and would most probably have been supplied by the military itself. [2] All other items could have been supplied by merchants driving oxen or pack trains. Many such traders may have been itinerant, such as the peddlers of Medieval England (Salway, 1965, 25). Some came from far away: Regina's tombstone (RIB 1065) set up by Barates of Palmyra, as well as Victor's tombstone (RIB 1064) at South Shields are suggestive of Palmyrene influences. As for the latter, it seems to have been "carved

---

[1] Grain would have represented the most quantity of any material supplied to forts in the North-east, requiring in the early 3rd century (discussed above, 2.2.2) 5,076 cart-loads, or 143 cart-loads per fort of 480 soldiers annually.

[2] As discussed (above, 2.2.3), by the late Empire, official systems such as the cursus clabularius transported food supplies, while the cursus velox conveyed valuable goods such as soldiers' pay, and it is likely that such a system existed throughout the Roman period in Britain for the protection of valuable and essential items.

by a sculptor trained at Palmyra who had partly adapted himself to the requirements of a very different market" (Bidwell and Speak, forthcoming, 13). In Carlisle, an inscription on what appears to be a 4th century coffin lid records the death of a Greek named Flavius Antigonus Papias. It is also possible that veterans became private traders after their retirement (CIL 13.6677).

6.2.1 Origin: Ports serving the North-east

Supply from York

Not only was York the traditional command centre[1] for the auxiliary forts in the North-east, it was probably the main entrepôt for overland supply to all three areas of the North-east. As discussed, much evidence attests to large-scale supply to York by ship from both the south of Britain and the Continent, and York may have remained the main port for supplies to the North-east from the Conquest to at least the mid-Antonine period. Although a certain amount of ox-transport would have been essential, after the initial post-Conquest period, perhaps most items could have been transported from York to all three areas of the North-east by pack animals.

---

[1] The fortress had been established in the centre of Brigantian power during the Conquest, when the Brigantes posed the major threat in the north. From York both the central Pennines and the hills of the East Riding could be controlled, while any large-scale movement southwards across the Humber or east into the territory of the Parisi could be checked (Salway, 1965, 5). With the 3rd century division, York became the capital of Britannia Inferior.

Area 1. Dere Street was constructed in the Flavian period, as attested by late 1st century dates at Binchester and Ebchester, as well as excavation of the road at Piercebridge (above, 3.1.2), and used continually throughout the Roman period (Margary, 1973) as the main route from York to the North-east. Having crossed the Tees at Piercebridge, Dere Street proceeds over relatively flat terrain until Scotch Corner. From this point north, the course of the road, running over the Pennine Spurs, seems to have been dictated by strategical requirements such as naturally defensible fort sites, and favourable river crossings (Steer, 1938, 45; discussed below, 6.3). Indeed, Binchester, Lanchester, and Ebchester are all situated on bluffs overlooking a river crossing. Materials could have been transported by ox-cart from York to Piercebridge and Binchester in six days, Lanchester and Ebchester in seven, while pack animals could have reached Piercebridge, Binchester, and Lanchester in two days, Ebchester in three. If indeed Binchester was a 'holding depot', all of the forts in Area 1 could have been supplied from Binchester (via York) in one day by ox-carts or pack animals.

A later date has been argued by some for a road running from York to Middleton St George on the Tees, through Durham City and Chester-le-Street, to Wreckenton on the South bank of the Tyne, parallelling Dere Street in the east. On the basis of a late 2nd century construction date at Chester-le-Street (Gillam and Tait, 1968, 85, 95) and construction of the fort and therefore a bridge at Newcastle at its terminus sometime after 165. However, as discussed (3.2), recent excavations have suggested an earlier fort at Chester-le-Street, and

although uncertain, it is possible that this site even may have had a Flavian occupation. The case of Newcastle will be discussed below. For now, it is possible that this road was Flavian. If a Flavian Chester-le-Street fort existed, it could have been supplied from York along this road in seven days by ox-cart, and in three by pack animals.

This road is connected to Dere Street by two branch roads. From Chester-le-Street a road branches south-west to Lanchester (Fawcett, 1966), and from Durham City another road branches south-west, meeting Dere Street north of Binchester (Wright, 1938; Margary, 1973). Chester-le-Street could have been supplied from York via the branch road and Dere Street by ox-cart in seven days, by pack animals in three.

Area 2. The Agricolan fort at Red House as well as the adjacent forts near Corbridge, most likely 'holding depots' (discussed above, 2.2.2), were situated at the junction of Dere Street and the Stanegate running to the west. Although the route between Corbridge and the North Tyne is uncertain,[1] once across the North Tyne, it skirts Warden Hill to the east to Thorngrafton Common, drops into the valley of the Brackies burn, and then ascends parallel to the Whin Sill. The Stanegate was constructed along the Tyne-Solway corridor under Agricola AD 78-83 as a link between the two trunk roads running north - Dere Street in the east and the Chester-Carlisle road in the west. This corridor, accessible

---

[1] Bennett (1990, 41) argues that it follows the river terrace on the north bank of the Tyne, and crosses the North Tyne near Warden.

all-year round, is the shortest distance between coasts in the country, and follows a gentle route through the valleys of the Eden/Irthing, South Tyne and Tyne (Bennett, 1990, 502). The interpretation of the function of this road favoured here is that it was not a 'frontier',[1] but rather, following Vegetius, a transportation and communication route linking two Roman trunk roads, perhaps built over a pre-Roman period road.[2]

The forts at Corbridge/Red House could have been supplied from York by ox-carts in eight days, pack animals in three. From here, as will be discussed, ox-carts could have supplied all the forts west of Dere Street in Area 2 in two days, while pack animals would have required only one day.

Although its course east of Corbridge is less certain, the eastern Stanegate may have been constructed south of the Tyne, similar to the route in the west, where the road runs south of the Solway. From Dere Street south of Corbridge, the road may have linked a Flavian fort at Ebchester (Bidwell and Holbrook, 1989, 150) with two overlapping forts at Washing Well near Whickham, thought to date to the pre-Hadrianic (McCord

---

[1] Since even the strongest advocates of a Stanegate 'frontier' argument would agree that the road was also used as a communication/transportation route, it is not necessary to venture into the argument.
[2] Indeed, as discussed (above, 2.2.1), the forts are placed about one day's journey apart by ox-cart.

and Jobey, 1971, 120).[1] From Whickham, the Stanegate may have joined the known Roman road of Wreckendike (Wright, 1940a) running to South Shields. As mentioned (4.1.1), ceramic evidence at South Shields suggests a Flavian occupation (Birley, E B, 1961, 155; Bidwell in Daniels, 1989, 83-84; Bidwell and Speak, forthcoming), and therefore a possible terminus of the Stanegate.

North from Corbridge, Dere Street most likely initially ran into Area 3 near Halton Chesters,[2] after which it was re-aligned to run through Portgate.

Area 3. The course of Dere Street across Area 3 is again dictated by strategical requirements. Forts were constructed at vulnerable river crossings (discussed below, 6.3), and never more than a one-day's ox-cart journey from each other. Although the stone fort at Risingham dates from the Antonine period, given its position as a bridge-head fort, it is possible that a Flavian occupation existed at this site. If so,

---

[1] Alternatively, Bennett (1990, 50) describes a route following Hedley-on-the-Hill to High Spen, dropping to cross the River Derwent at Winlanton Mill and on to Washing Well, and following the parish boundaries via the Team Valley to the Wreckendike.

[2] Immediately north of Corbridge, Dere street in its original form may have taken the course followed by a minor modern road, which runs east of the later Dere Street route for the first few kilometres, thus eliminating the steep lower slopes directly north of Corbridge, before turning north to run through milecastle 22 and meeting the later alignment of Dere Street somewhere near Little Whittington (Bennett, 1990, 145).

Risingham, Blakehope and High Rochester [1] could have been supplied from York by ox-cart in nine, nine and ten days, respectively, and by pack animals in three days.

Branching-off Dere Street just beyond Portgate, the Devil's Causeway runs north-easterly to Berwick-upon-Tweed on the North Sea. Dated by pottery and excavation (discussed above, 5.3.1; Appendix J-2.2), the first fort at Low Learchild probably dates from the Flavian period. This fort could have been supplied from York in ten days by ox-cart, three days by pack animals. Alternatively, supplies could have been sent to High Rochester and 'held' (discussed above, 2.2.2) before being sent to Low Learchild along the Bremenium-Thrunton cross road to Low Learchild.

Supply from the West Coast

As discussed, a port on the Solway Firth may have received ocean-going ships with provisions destined for forts in the North-east from the Flavian to mid-Antonine periods. Early west-east supply along the Stanegate is suggested by ceramic 'tracer$'. A type of jar or cooking-pot thought to have been produced at Brampton, occurs frequently at Vindolanda in the levels of periods II and III (Hird, 1977, no 229). This style also appears in early levels (Richmond and Gillam, 1955) at Corbridge (87/48 GE59 and 87/99 IS64 in Bishop and Dore, 1988, 257, 258),

---

[1] Pottery recovered at Blakehope is of the late 1st or early 2nd century, while two Flavian forts are known at High Rochester (Daniels, 1978, 295-6).

and because it is absent at Red House fort, the supply of such pottery along the Stanegate may have begun in the Trajanic period (ibid.). Overland transport from the west coast in this period is also attested by a Vindolanda writing tablet (above, 4.4.1), if in fact Briga is Kirkbride. The journey from Carlisle to Vindolanda (ca 46km) would have taken two days by ox-cart, and three to Red House/Corbridge, while pack animals could have made the journey to both sites in one day. Once there, forts could have been supplied north and south along Dere Street, or east along the Stanegate.

The distribution of BB1 ware (above, 6.1.2) attests to continued transportation along this route throughout the first Hadrianic Wall and Antonine Wall periods. After construction of Hadrian's Wall and the movement of forts to the Wall line, supplies would have been transported east along the Stanegate, and delivered to the forts (with the exception of Carrawburgh[1]) over branch roads which were carried over causeways after construction of the vallum. Chesters, Carrawburgh, Housesteads and Great Chesters could have been supplied from a West Coast port by oxen in three days, by pack animals in one day.

---

[1] Although not provided with a branch road, antiquarians identified a track on either side of Carrawburgh fort at Wall Mile 28 (Gordon, 1726, 74) and Wall Mile 32 and 33 (Horsley, 1732, 118, 146), varying in width from 2.1m to 4.3m. Running between the Wall and the later Military Way, this track has since been called the 'Lesser Military Way' (Birley, E B, 1961, 115; Bidwell and Holbrook, 1989, 153). Since it is not known elsewhere, it may have been constructed on an ad hoc basis to link Carrawburgh, a later Hadrianic fort, with Chesters and Housesteads and thus to the supply network.

As the lack of vallum causeways at milecastles may have precluded supply to the milecastles directly via the Stanegate,[1] they were probably supplied via a track along the north berm of the vallum.[2] Indeed, not only are the berms very wide at 5.45-9.14m (Bennett, 1990, 420), as part of the vallum they are very straight, without obstacles, and constructed over a direct route (more so than the Wall; Williams, 1983, 36).

Supply from Berwick-upon-Tweed

The existence of a port at Berwick-upon-Tweed is suggested by the terminus of the Devil's Causeway. As discussed in Appendix J-2, this road may have functioned in a variety of ways, one of which must have been to secure sea-borne supplies; in addition, the lack of garrisons along this road suggests that it was abandoned as a supply medium most likely before the beginning of the 2nd century. If Berwick-upon-Tweed received sea-borne supplies during this brief period, Low Learchild could have been supplied by ox-cart down the Devil's Causeway in two days, and by pack animals in one day. Using the road branching from the Devil's Causeway west from Low Learchild, High Rochester and other Flavian installations along Dere Street could have been supplied in four days by ox-cart, two days by pack animals.

---

[1] It is possible, however, that wooden bridges were constructed across the vallum, all traces of which have completely disappeared.
[2] Horsley, 1732, 120; Birley, E B, 1949, 24 and 1961, 122-123; Dobson, 1986, 25; Williams, 1983.

Supply from South Shields

As discussed, ceramic evidence and construction of a stone fort at South Shields suggests that the site had become the dominant port in the North-east by the mid-Antonine period. By this period, demands for grain, as well as other bulky supplies apart from those in amphorae, barrels, and chests could have been at least supplemented if not entirely met by local production. Therefore, only Baetican imports and possibly barrels from the Dutch and Atlantic coast ports, as well as soldiers' pay would have been transported by ox-cart, while almost everything else could have been transported by pack animals. By the Severan period and most likely through to the end of the Roman period, grain was shipped to South Shields for delivery throughout the North-east, again necessitating large-scale ox-transport.

Area 1. From the mid-Antonine period, supplies shipped to South Shields could have been transported overland to forts in Area 1 via the Stanegate/Dere Street route. Ebchester could have been supplied along the Stanegate in two days by ox-cart, one day by pack animals, and from here, supplies could have been sent down Dere Street. Via Dere Street, ox-carts from South Shields could have reached Lanchester in two days, Binchester and Piercebridge in three days, while pack animals would have required just one day for the supply of all three forts.

Alternatively, supplies could have been transported along the road running parallel to Dere Street in the east. Indeed, ceramic evidence

recovered from excavations at Chester-le-Street has dated the fort and therefore the road to the Antonine period at the latest (discussed above, 3.2). From this road, supplies could have been sent to forts along Dere Street via the two branch roads. Binchester, Lanchester and Piercebridge could have been supplied thus in two, three and three days, respectively, by ox-cart, and one day by pack animals. If Binchester was indeed a 'holding depot', it may have held supplies from South Shields both for Lanchester and Piercebridge.

Area 2. The eastern end of the Wall. As discussed, the position of South Shields behind the eastern terminus of both the Wall and a river running behind the Wall suggests that the fort may have received at least some sea-borne supplies during the first Wall period for Wall structures east of Portgate. Such supply may have been carried out overland from South Shields via the Wreckendike and a bridge at Newcastle. Although the stone bridge may have been constructed later, the site below Newcastle has traditionally been favoured as a crossing point. Indeed, before 19th century dredging operations, the Tyne could be forded at Newcastle during low spates (discussed below, 6.3.1). Therefore, it is likely that the stone bridge merely replaced an earlier bridge or ford on the same site.

Once across the Tyne, supplies may have been 'held' at Benwell (above, 2.2.2; below, 6.3.1) for Rudchester and Halton Chesters further west along the Wall, or transported directly via a road built immediately behind the Wall. Evidence attesting to such a road was recovered at

Denton Burn (NZ 201655) in 1987, where excavations revealed mason's chippings immediately behind the Wall and incorporated into a lightly-metalled surface up to 8.18m wide, carrying cart-ruts and apparently laid down soon after the Wall was built (Frere, 1988, 433). The surface had been patched, and then sealed by clay. Above this was a second road surface 5.56m wide sealing a coin of 202-10.

Alternatively, these forts may have been supplied by a service road running south of the vallum and following a course roughly along modern Elswick Road in west Newcastle (Bidwell and Holbrook, 1989, 153). Along this road, Wallsend and Benwell could have been supplied from South Shields by ox-cart or pack animals in one day, while Rudchester and Halton Chesters could have been supplied from South Shields by ox-cart in two and three days, respectively, or by pack animals in one day.

In addition to evidence cited, other evidence suggests that South Shields had become the dominant port in the North-east by the mid-Antonine period. First, communications between South Shields and the Wall forts were enhanced with construction of a new bridge at Newcastle perhaps at this time, which may have replaced an earlier bridge (discussed above). Indeed, construction of the Antonine bridge has been linked with construction of the fort at Newcastle: the fort is called Pons Aelius, and the gens Aelius was the family not only of Hadrian, but also of Antoninus and Commodus. In addition, ceramic evidence at the fort suggests a construction date between ca 164 to the reign of Commodus (pers comm John Dore).

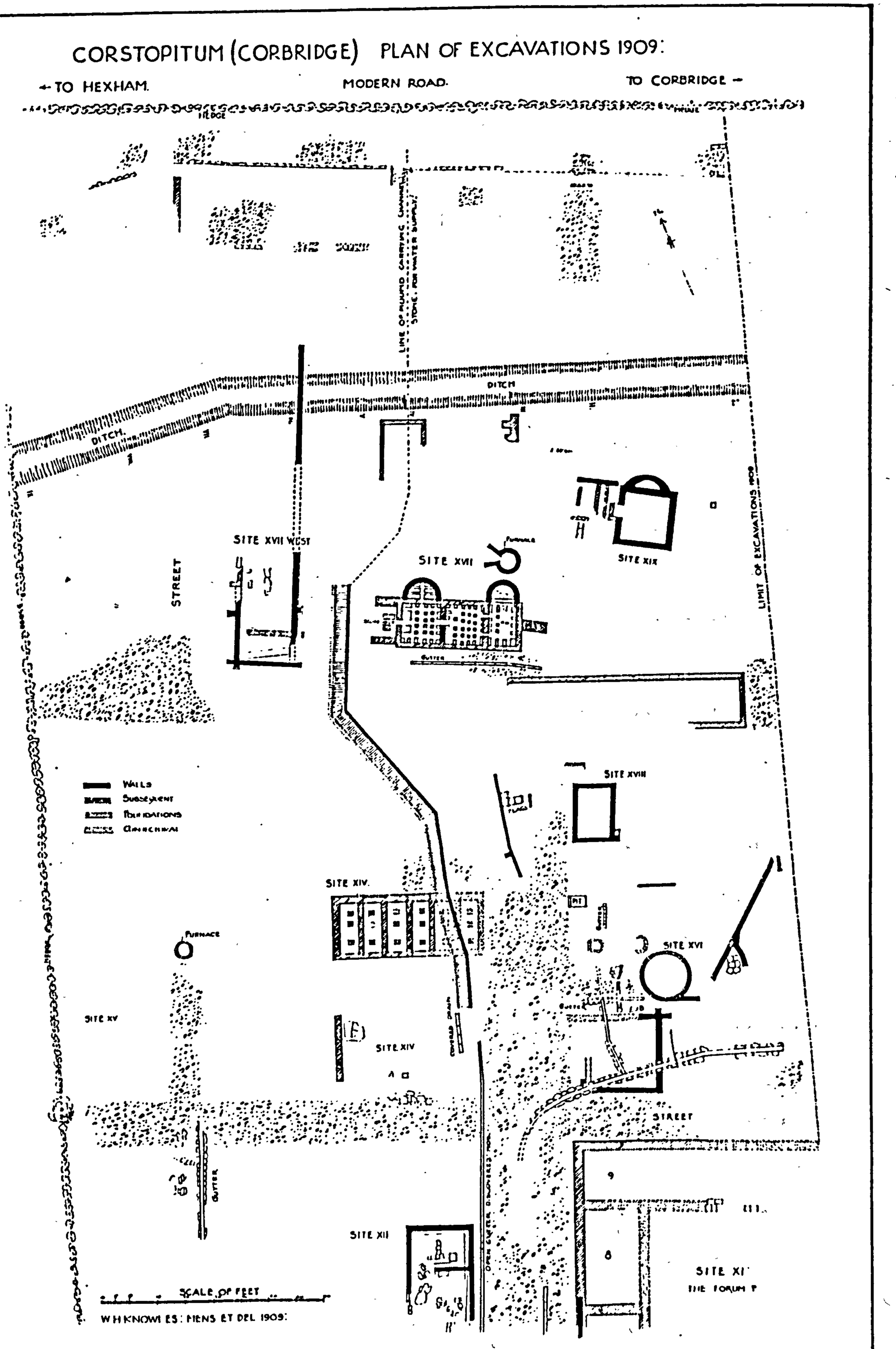


Fig 77: Plan from 1909 excavations showing one of two large granaries (Site XVII West) North of Site XI at Corbridge, from Forster and Knowles, 1910, plate XIII.

Second, the Military Way was constructed between the vallum and Wall along the entire length of the Wall in this period, further facilitating transport to Wall structures. Rather than the somewhat inferior road described above, Wall structures east of Corbridge were now serviced by a high quality road.

Corbridge. By the mid-Antonine period, evidence suggests that supply from South Shields to Corbridge, possibly conducted along the Military Way, was very important. Indeed, situated at the junction of the Stanegate and Dere Street, and near the Military Way, Corbridge had by now become, if it was not already, a 'hub' of the supply system in the centre of the North-east. It seems that the Antonine period granaries, representing a full 2.93 per cent of the area within the fort, were constructed in the last phase of the fort, and at a time when the whole site had begun shifting from a predominantly military to civilian character. Indeed, aerial photographs attest to the burgeoning of the civilian settlement from the 160's to 24 ha in area, as well as the proliferation of strip houses, argued by some (Daniels, 1978 and 1989; Burnham and Johnson, 1979, 61) to have functioned as shops, workshops and other buildings. As at Carlisle, by the mid-Antonine period, Corbridge seems to have become a significant trading centre.

That Corbridge was a 'hub' of the supply system becomes even clearer with regard to the Severan period. First, as attested by RIB 1151 found

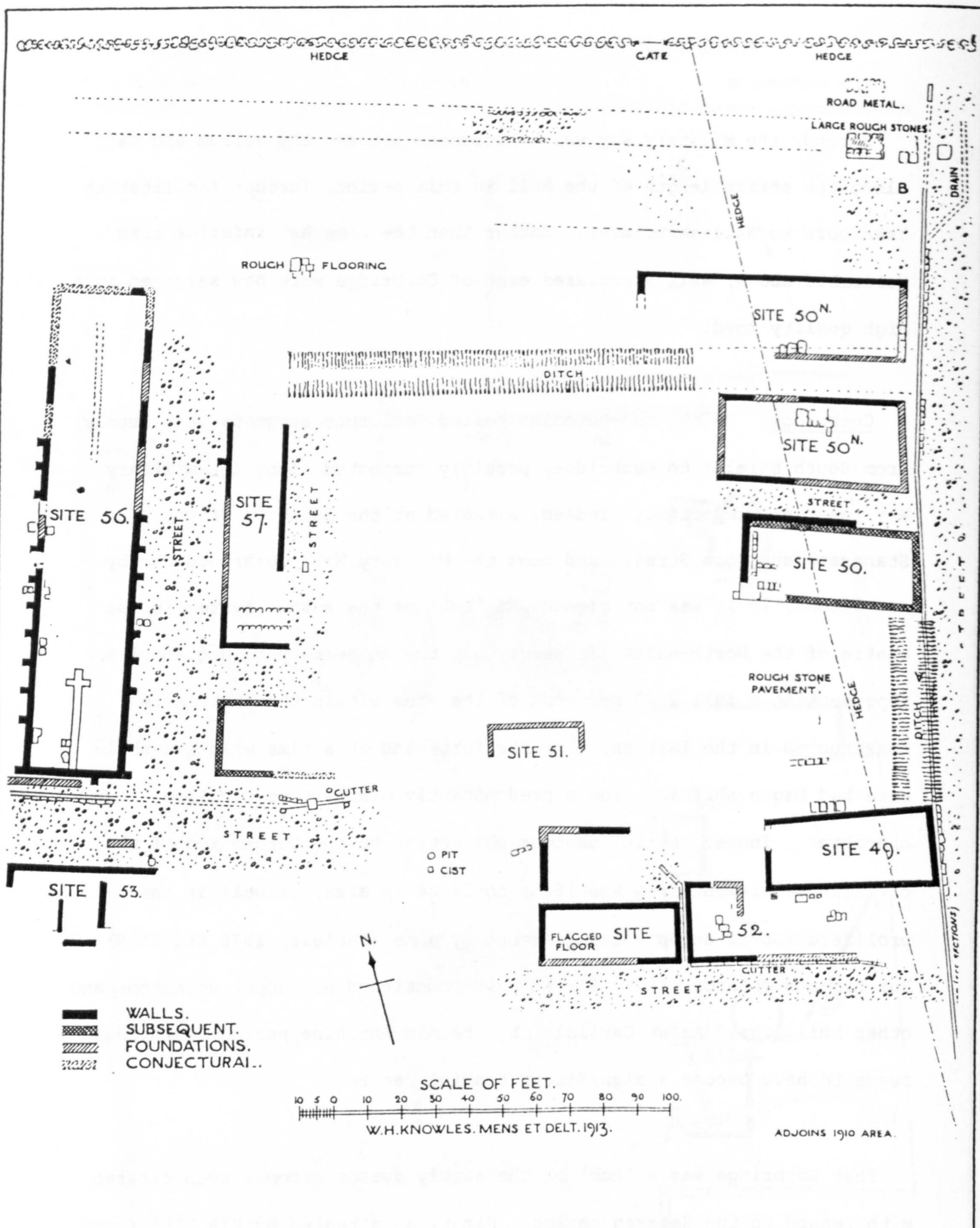


Fig 78: Plan from 1913 excavation showing second of two large granaries (Site 56) north of Site XI at Corbridge, from Forster and Knowles, 1914, plate VIII.

in Hexham Priory, the Antonine granaries were reconstructed.[1] Second, two large granaries excavated 1909-13[2] north of Site XI may also have been constructed during the Severan period (see figures 77 and 78). Indeed, the granaries were constructed after the site had ceased functioning as a fort, as attested by their position over an earlier infilled ditch. Further, another inscription (RIB 1143) suggests that a praepositus in charge of granaries at the time of Severus' campaigns dedicated new granaries constructed at Corbridge (Collingwood and Wright, 1965, 376-7).

That these granaries were filled at least in part by supplies from South Shields is suggested by the construction of intra-mural granaries at South Shields in the same period. The continued use of the large granary space at South Shields, together with the likely continuation of the Antonine and perhaps the Severan period granaries at Corbridge suggests that this link continued after the brief period of Severus' campaigns. From the Severan period, grain which had been shipped to South Shields and transported overland for storage at Corbridge may have represented the annona militaris collected from other areas of Britain.

A trade link between South Shields and Corbridge is further suggested by the above-mentioned tombstone (RIB 1065) erected by Barates of Palmyra

---

[1] RIB 1151 attests to work on a granary under Lucius Alfenus Senecio (202-208) (Collingwood and Wright, 1965, 380).
[2] The better-preserved eastern granary measured 45.7x9.14m, with internal dimensions ca 312m sq (Gentry, 1976, 75).

for his wife Regina at South Shields, of the late 2nd or 3rd century (Salway, 1965, 61). On the basis of the location of his wife's burial, it is likely that his household was in South Shields, and that he operated out of Corbridge.

Supplies from South Shields could have been transported to Corbridge overland by ox-cart in two days, and by pack animals in one day.

Forts west of Corbridge. It is argued (Dickinson and Hartley, 1971, 130) that the high ratio of East Gaulish samian stamps at Carlisle can be explained by an east-west trade along the Wall from the port at South Shields beginning in the Antonine period. Forts west of Corbridge could have been supplied from South Shields along the Military Way or Stanegate.

Indeed, the Military Way in this area was used in addition to the Stanegate, rather than as a replacement. Milestones, attesting to repair (RIB 2293, 2301-3), suggest continued use of the Stanegate until at least the early 4th century (Bidwell and Holbrook, 1989, 137). From South Shields, supplies could have been sent via the Military Way or Stanegate to Chesters, Carrawburgh, Housesteads, Great Chesters, and Vindolanda in three days by ox-cart, or one day by pack animals. All of these forts could have been supplied from Corbridge in one day by either ox-cart or pack animals.

Area 3. From the mid-Antonine period, supplies from South Shields could have been transported via the Military Way and Dere Street, or Stanegate, Corbridge, and Dere Street to Risingham and High Rochester by ox-cart in three and four days, and by pack animals in one and two days, respectively.

6.2.2 Origin: South Britain

In addition to supplies shipped to York from the Continent and South Britain for eventual distribution to forts in the North-east, the fortress workshop at York may have produced certain items for forts in the North-east.

Analysis of the hoard of ca 9,090kg mainly unused nails buried in a pit at Inchtuthil within what had been the fabrica suggests that a large number of nails were manufactured at the legionary fortress of Inchtuthil. In addition, the high quality of some of these nails together with the massive quantity requiring many man/hours of production suggests that at least some of the nails were imported ready-made from further south (Pitts and St Joseph, 1985, 112-113). Similarly, until fabricae in forts in the North-east began manufacturing their own supplies of nails, initial requirements may have been transported from outside the North-east. As York would have had work depots at least as substantial as Inchtuthil, and because the forts in the North-east were constructed by legionaries from the fortress at York, it seems likely that nails, as well as supplies such as arms, armour, tools and equipment

(described below), initially would have been transported from fabricae in York. However, as discussed below, it is likely that very soon after the Conquest much material was produced in fabricae of forts within the North-east.

Second and third century Midlands ceramics probably would have been transported overland to the North-east. The Nene Valley was well-established as the major supplier of mortaria by 270 (Gillam, 1973, 59), and Mancetter (Harts Hill) ware was also very important in the North-east.[1] Special service roads leading from the Mancetter kilns to Watling Street and from the Hardham complex to the main Harlow-Braughing road (Swan, 1984, 19, 48) suggest overland transport, and Hartley (1972, 39) argues that "the distribution of mortaria from Hartshill and Mancetter offers clear evidence of the use basically of road transport".

In addition, Dales ware, the supply of which effectively eliminated Midland and southern competition (such as BB2 and Colchester mortaria) for the northern military market in the 4th century (Gillam, 1973, 61), was produced in kilns near Dere Street on Humberside, Yorkshire. As discussed, coarse-wares for cooking likely would have been transported overland by private traders driving ox-carts.

---

[1] This may have been because they produced a variety of different wares, and because they were the furthest removed from the Continent and the competition of Central Gaulish and Rhenish potters (Fulford, 1977a, 309).

Coarse-wares likely represent the extent of bulk shipments overland to the North-east from areas south of Yorkshire. Other bulky items, such as grain, most likely would have been transported to the nearest port and shipped to York, a port on the Solway Firth, Berwick-upon-Tweed, or South Shields. Although some of the non-bulky South British items would have continued to be supplied by sea along these routes, as discussed, the lack of BB2, Colchester mortaria, and other ceramics suggests against large-scale supply to the North-east along the east coast in the later Roman period. Rather, most non-bulky items were by this time probably transported overland by individual traders. These items include: glass, mirrors, fine-ware ceramics, salt, brooches and other jewelry, drink, luxury foods, and textiles.

6.2.3 Origin: Local Supply

Fort Environs

Forts. Much evidence from forts in or near the North-east suggests that arms, armour, tools and other equipment could have been produced in forts from an early period. In Area 1, recent excavations at Binchester in a military context have recovered a large area used for metalworking, mainly iron smithing, over the remains of what probably were demolished Flavian barrack blocks (Jones, R F J, 1990, 104).[1] A 1m deep layer of

---

[1] Pottery suggests a fully 'Roman' character which, given the time frame, is military (Jones, R F J, 1990, 104).

slag, charcoal, dumped rubbish and hearths was recovered, over which the first stone fort of the 2nd century was constructed (ibid.). In total, it seems that this post-Flavian site at Binchester was devoted mainly to industrial works, in lieu of conventional fort buildings, and the scale of the operation suggests that these industrial compounds were producing goods for distribution to other forts (ibid.).

Epigraphic evidence at Vindolanda mentioned above (4.4.1; Inv 88/946) suggests that Catterick, just south of Area 1, was the production site of hundreds of hides destined for Vindolanda, and that they were produced by the military sector (Bowman, Thomas and Adams, 1990, 42). That such large numbers of hides were produced at Catterick is supported by archaeological evidence for masses of organic waste found in the fort annexe dated from the Flavian period to ca 120 (Wacher, 1971, 170), while large, deep pits dating to the mid-2nd century and situated beyond the later town wall to the south suggest a continuation of this work (Burnham and Wacher, 1990, 111 and 116).

In Area 2, a workshop from pre-Hadrianic period Vindolanda is attested by a writing tablet (Doc. 1; Inv. 195, 198; Layer 10) which records 343 men in fabricis (Bowman and Thomas, 1983, 77-79). Several of these men seem to have been concerned with building materials or with construction, and possibly were employed in the workshops when not on active campaign:

> "April 25, in the workshops, 343 men. Of these: shoemakers, 12; builders to the bath-house, 18; for lead ...; ... hospital ...; to the kilns ...; for clay ...; plasterers ...; for rubble...;"

The men detailed ad furnaces ("to kilns") for firing clay (Bowman and

Thomas, 1983, 79), and ad lutum ("to [acquire] clay"), may have been producing tiles and bricks for construction (ibid.).

The writing tablets themselves could have been produced locally. Indeed, pollen diagrams indicate that both alder and birch were common throughout the North-east in the Roman period (Davies and Turner, 1979).

As discussed above (2.2.2), evidence at Red House attesting to a large fabrica and worksheds, suggests that this site functioned as a depot producing supplies for Flavian period forts in the North-east. That such functions were carried out by soldiers garrisoning the later forts near Corbridge is suggested by artefacts found in a hoard sealed beneath the floor of a 1st century fabrica (Daniels, 1968). It seems that swords, daggers, and spear heads could have been produced, while loricae segmentatae could have been repaired in the fort fabrica. Evidence also exists of industrial activity within the first post-fort principia (Bishop and Dore, 1988, 22), an area which also may have served as a military storehouse (Burnham and Johnson, 1979, 60). Industrial activity in this period is also attested by ovens and hearths and associated timber structures found at Sites 9 and 20, and possibly Site 44 (Bishop and Dore, 1988, 139). In addition, water was supplied to two Severan period works depots by channels from the rebuilt fountain-head and settling tank of the aqueduct (ibid.).

Also in Area 2, two offices north-east of the aedes at South Shields were used as a smithy in Period 5 preceding construction of the Severan

supply base (Bidwell and Speak, forthcoming, 25-26).

At Newstead along Dere Street north of Area 3, metalwork has been found in Pit XVI, including ninety-six pieces of partly worked or unworked iron - tools, weapons, mountings, and odd pieces of metal. Elsewhere at Newstead, the recovery of spears, axes, hammers, chisels, tongs, mountings for saddles, hub-linings for wheels all suggest a camp forge (Curle, 1911, 277).

The production of the items above suggests a potential to produce within forts the following necessary items: arms and armour - helmet crests, helmets, face protectors, shields, bows and arrows, knee breeches, buckles, bridles, bits, and artillery; tools - picks, sickles, chains, and scythes. These items could have been produced intensively in some forts and distributed elsewhere, or individually at each fort fabrica.

Settlements adjacent to forts. Soldiers may have secured supplies from civilians living in settlements adjacent to the forts: indeed, archaeological evidence attests to such a presence at nearly every fort in the North-east. Although merchants, shopkeepers and craftsmen who supplied the rank and file with off-duty luxuries and entertainment had been considered a nuisance under the Republic (Caesar, B Gall, 6.37), after units had become settled into semi-permanent or permanent positions, these civilians became increasingly tolerated and even necessary (Salway, 1965, 25). These civilians, including prostitutes,

merchants, and soldier's families, may have taken up residence outside most of the forts in the North-east from a very early period, following the army on its northern progress (Breeze, 1990, 90).

Eventually, these settlements may have functioned as market centres, receiving goods imported from long distances away, or produce from the native farmsteads and villages, operating out of small, narrow, open-fronted 'shops'. In addition to the wealth of artefacts recovered on these settlements, the position of these narrow buildings opening onto the main streets and as close to the forts' gates as possible, suggests a competition between civilians for trade with the forts' garrisons (Higham, 1986, 219). By the 4th century, settlements at Corbridge, Piercebridge, and Lanchester may even have reached the status of 'towns' (Clack, 1982, 397).

In addition to functioning as 'middlemen', metalworking by civilians in the these settlements is suggested by dedications to Vulcan set up by civilians in settlements at Vindolanda and Old Carlisle (Salway, 1965, 26). Further, an above-mentioned (4.4.1) Vindolanda writing tablet (Inv. 85/51) describing production of wagon parts at the site also seems to suggest that both sender and recipient were civilians working for the military under contract, rather than soldiers (Bowman and Thomas, 1987, 140-1).

Lands attached to forts. It is possible that lands were attached to auxiliary forts as territoria were to legionary fortresses. Much evidence attests to territoria, or "lands or territory under a particular authority" (Pomponius Chorographia 50.16.239.8), or "the area where an officer's writ runs" (ibid.) which were under the responsibility of the conductores faenarii and pequarii. Such land provided ground for military installations and practice ranges, as well as at least some of the soldiers' provisions. The use of such lands for the latter purpose seems to have changed throughout the Roman period. On 1st century AD boundary stones found in Hispania, Tarraconensis and Dalmatia, areas within legionary control were referred to as prata, or literally 'pasture', rather than territoria (Mócsy, from Mason, 1988a, 164). This pasture would have been used for horses as well as draught animals and possibly other livestock. Presumably territoria would have been exploited for building stone and timber for building and fuel, as well as game.[1]

However, by the middle of the 2nd century, a legion's land is usually referred to as territoria rather than prata, suggesting a functional shift. Indeed, the legionary lands began to support civilians living in extra-mural settlements - the canabae legionis - as well as civilians living in farmsteads and villages in the hinterland, as suggested by tile

---

[1] It seems that soldiers were permitted to hunt providing they did so off duty (Dig 49, from Davies, 1971, 124).

stamps.[1] It is indeed conceivable that this land had passed over in large part to civilian cultivation. The majority of tile stamps near Vindonissa were found in isolated farm buildings, suggesting that they were occupied by tenant farmers holding leases from the legion, over a total area of 1300km sq (Mason, 1988a, 166). Petrikovits (1960, 63) argues on the basis of evidence from epigraphy, tile stamps, and field survey that the territorium at Vetera near Xanten on the Rhine was fully 1,417 ha in area and may have satisfied the food requirements of the entire legion. Indeed, a situation may have developed whereby a legion 'leased' parts of the territoria to 'tenants' in return for agricultural produce (Hurst, 1988, 69).

Although ultimate authority over the military territory of the North-east probably devolved upon the legionary legate in York for most, if not all of the Roman period (Salway, 1965, 189; Mason, 1988a, 162), it is likely that a considerable amount of land in the frontier area was controlled by each individual auxiliary fort (Salway, 1965, 189; Manning, 1975). That such lands were attached to forts in the North-east is suggested by the inscription RIB 1049 at Chester-le-Street (discussed above, 3.2.2), which mentions the fort territorium. In addition, as very few native settlements are known in the area between Hadrian's Wall and the vallum in the early Roman period (pers comm C M Daniels), it seems that for this period, at least, the area was restricted to military use.

---

[1] Numerous stamped legionary tiles found in civilian buildings must have been supplied officially by the legion (Mason, 1988a, 166).

Therefore, as auxiliary forts seem to have had lands similar to fortress territoria, it follows that lands attached to forts were exploited in the same ways as territoria.

If so, raw materials and pasture for horses, baggage and draught animals, and livestock would have been fully exploited. As for arable farming, many forts in the North-east are placed over or near land which had been cultivated before and during the Roman period (discussed in Appendix D), so that it is conceivable that lands lying within a fort's territorium supplied food to the requisite fort's garrison. Such lands may have been worked by civilians as were legionary territoria.

Transportation to forts in the North-east of supplies produced in fort fabricae or in associated civilian settlements and attached lands could have been carried out with little difficulty over native trackways or Roman period roads.

Further Afield

Romano-British Settlements. The army may have received supplies from the many native settlements in the North-east, either directly or vicariously through settlements adjacent to forts.

It has been argued traditionally that because less Roman period artefacts have been found on settlements across Areas 1 and 2 than in other areas, such as the Brigantian lands of the nearby Yorkshire Wolds

(Evans, J, 1984, 47),[1] and because only one villa is known in the North-east,[2] the army did not receive supplies from the local population. However, two reasons may explain the lack of artefacts and villas. First, the tribal system within Brigantia was different before and during the Roman period (Haselgrove, 1984). The main urban centres - the municipium of York, the Brigantian civitas at Aldborough, and that of the Parisi at Brough (Jones, R F J, 1984a, 40) - contained not only craftsmen and traders, but also a local 'aristocratic upper class'. These filled important posts in the municipium and civitates, and relied on 'trappings' of wealth and rank to indicate their position in the Roman province. On the other hand, Area 1 consists of a number of individual 'petty chiefs' (Richmond, 1954, 45) of the Brigantes, which may not have demanded artefacts to bolster prestige or position.

> "What was lacking was a well-developed political and ideological superstructure which Rome could readily make use of, and most obviously, a numerous elite whose position was founded on absolute distinctions of rank and wealth. As a result, the settlement pattern took on an appearance which was much less "Roman", its towns and villas lacking the elements of elite competition and display so evident in their southern counterparts."
>
> Haselgrove, 1984, 22

---

[1] Although material found south of the Wall does provide evidence of at least a limited supply economy (Higham, 1981), it was not one that was either continuous or particularly significant within the farming economy (Higham and Jones, 1983, 63). Generally, the artefacts recovered on settlements in Area 1 consist of small amounts of inexpensive products such as mass-produced pottery, beads, bangles, and the like (Higham, 1989, 166). As for coinage, it is so rare that it is unlikely to have been used for anything except barter (Robertson, 1970; 1983).

[2] Holme House near Piercebridge has been discussed (above, 3.1.2). In addition, a bath-house at Old Durham suggests a certain degree of 'Romanization' in the area (Richmond et al, 1944).

Second, supplies could have been gained on a local level either from fort territoria or settlements by taxation-in-kind (see Breeze, 1984; 1990, 90; Davies, 1974, 316), without an exchange of coinage or artefacts (Higham, 1989). Tacitus (Agric., 19.4) records that for the Conquest period, grain and other supplies were requisitioned and delivered directly to the forts,[1] and that officials were involved in extortion: they apparently bought up British crops and forced natives to buy from them at inflated prices the grain which the army levied from the local population.[2] In the 2nd century, two papyri refer to the purchase of 200 and 775 blankets for the army (P Oxy 2230 and 2760), and by the time of Severus, provincials were taxed on a regular basis with the annona militaris.[3] A R Birley (1981, 43) argues that the annona was not a specific tax, but rather a name attached to batches of supplies received as taxation in kind, when these supplies were destined for the army. As discussed (2.2.2), mansiones were extended under Severus to store this produce, collected by the soldiers in charge of the service and managed by an actuarius (A R Birley, 1981, 43). By 319, the Theodosian Codex (7.4.15) states that "the praetorian prefect was instructed to order supplies of subsistence allowance to be brought to the camp by the provincials nearest to the borders". The annona system seems to have

---

[1] In this way, the grain supply was organized so that the tribes were not required to deliver shipments over long distances.
[2] Haverfield (1916, 102) argues that a corrupted Carvoran modius is evidence for this official extortion: this vessel held .28 litres more than the 9.54 litres (17.5 sextarii) it was meant to contain. However, this discrepancy of 2.85 per cent is well within the limits of error found on ancient measures (Frere and Tomlin, 1991, 58-59).
[3] This resulted perhaps from a debasement of coinage under Severus (Hopkins, 1980, 115-116).

been in place until the end of Roman Britain (Rickman, 1971, 278-83).

Therefore, the lack of artefacts may be explained by the enormous military presence skimming the surplus of agricultural produce from the natives in the North-east in the form of taxation-in-kind, rendering the natives unable to accumulate sufficient capital in the form of coinage or barter items which could have purchased or been traded for artefacts from the settlements adjacent to forts (Higham, 1986; 1989). The lack of villas can be explained by the absence of an Iron Age aristocratic stratum in this area which could have assumed the position enjoyed by the Roman period Yorkshire elite; again, such a class may have been unable to develop throughout the North-east because of the Roman army's voracious and consistent demand for local surplus production (Higham, 1986; 1989).

As Area 3 was outside the Empire for most of the Roman period, it has traditionally been held that the Roman army obtained very little, if any, supplies from this area. However, two factors suggest a certain amount of trade. First, small settlements (.16-.8 ha) moved towards military establishments during the Roman period (Kurchin, 1983), and excepting Traprain Law or Yeavering Bell, large sites seem to have been abandoned[1] while small homesteads[2] proliferated. During construction

---

[1] At Hownam Law and Arthur's Seat, small homesteads seem to have been superimposed on the ruins of earlier ramparts (Feacham, 1977, 151, 135).
[2] These homesteads are rectilinear, with 2-4 stone houses, a forecourt, cattle pounds, surrounded by a low stone-faced wall or ditched earthen embankment. It must be noted that these began to emerge before the Roman advance, as proven at Huckhoe, Burradon, and Belling Law (Jobey, 1959; 1970).

of Roman forts, signal towers, and roads in the earlier part of the Roman period, the settlement pattern of these homesteads shifts from the hills to the lowland area between the Tyne and Wansbeck, particularly in the North Tyne Valley and Redesdale. Further north in Berwickshire, the Lammamuir Hills seem to have been abandoned for sites further west nearer the Lothians and Dere Street (ibid).

Second, the post-Conquest expansion of Traprain from 12-16 ha, as well as samian and Romano-British pottery found on many Votadinian sites suggests not only a benign relationship, but perhaps one that allowed a certain degree of reciprocal trade (Kurchin, 1983).

Although not within the province for most of the Roman period, those natives who settled near Roman forts in Area 3 nevertheless may have exchanged such items as surplus food supplies in exchange for 'protection' from the local fort garrison.

Supplies. As for grain supply in the North-east in the Roman period, as discussed in Appendix D, much cultivation was carried out within this survey area. However, production levels of grain in the North-east are likely to have varied according to the time period. As discussed fully in Appendix H, after the initial post-Conquest period, the grain demands of the soldiers, military animals (including fodder for cavalry horses, draught and baggage animals), and native population may have been satisfied by local production until about the end of the 2nd century, after which South Shields became an entrepôt for imported grain.

The army had an enormous demand for both meat and hides, and for the early period, it is clear from Tacitus (Ann 4.72) that cattle, like grain, were subject to compulsory purchase. When describing the German frontier in AD 58, Tacitus states (Ann 13.54, 55):

> "The Frisians... [moved in and] settled in fields that were empty and set aside for the use of the soldiers.... [and in a speech by Boiocalus] ... 'Why does so much land lie idle for the occasional introduction of the flocks and herds of the soldiers?'"

The high proportion of cattle bones (91 per cent of estimated meat consumption) at Vindolanda and at Corbridge (91.7 per cent) attests to a bias towards beef consumption. However, a writing tablet from Vindolanda (Doc.5; Inv. 11; Layer 8) also attests to the purchase, presumably from the local population, of roe deer (capream), young pig (porcellum), ham (pernam), and venison (ceruinam) (Bowman and Thomas, 1983, 94).

Local supply of meat after the Conquest is suggested by faunal remains at Vindolanda. The high recovery rate of immature bones suggests that native farmers were being forced to provide animal products for the army (Branigan, 1984, 30). Further, the sample of animal bones recovered from Corbridge is similar in both frequency and types of different species to Catcote civilian settlement (Hodgson, G W I, 1968, 128),[1] suggesting that the soldiers' diet was very similar to that of the natives. Moreover, the cattle bones at Corbridge are all of Celtic Shorthorn which could have been raised locally (Hodgson, G W I, 1968).

---

[1] The order of abundance of species present at each site is ox, sheep, pig, horse, and red deer (Hodgson, G W I, 1968, 128).

In Area 3, evidence on Romano-British farms suggests livestock raising was common in the Roman period. As discussed in Appendix D-3.2, Romano-British farmers in the North-east grew crops and raised livestock at different times of the year. Gates (1981, 33) argues that "it begins to look as if crops and hay were grown in fields around dispersed farmsteads, while animals were driven out to graze more distant moorland pastures in a time-honoured seasonal cycle".

Vindolanda writing tablets also attest to soldiers purchasing beer (Doc. 4; Inv. 33,47,62; Layer 8). Soldiers even may have made their own, as suggested by the purchase of emmer (bracis) (Doc. 4; Inv. 83/11; Layer 8) used in malting (Bowman and Thomas, 1983, 96).

If not raised locally, the many horses required in the North-east could have been brought from other areas on the hoof. The same can be said for oxen, mules, and asses used as beasts of burden.[1]

Necessary clothes such as skirt, tunic, knee breeches, underclothes, and socks could have been produced locally. Late Iron Age weavers had developed an advanced technology which was little affected by the Roman Conquest, except in the processes of dyeing and finishing the textiles (Wild, 1979, 127). At Vindolanda, a number of woollen textiles have been

---

[1] However, while the range of different sizes of ox bones at Corstopitum show that some beasts were larger in the Roman than preceding period, leading some to consider that an Italian breed may have been introduced into the native stock in the Roman period (Jewell, 1963), nothing suggests that they were not raised locally.

recovered, displaying a high proportion of very competently woven diamond twill cloth, most likely produced by the local population:

> "The general character of the collection, the types of wool fleece from which the yarns were spun and the thrice-repeated technique of combining bands of Z-spun and S-spun yarn point to native weavers as the source of supply, whose working methods were still Iron Age."
>
> Wild, 1979, 127

Many weaving-combs common on Iron Age sites in Britain have been found in northern forts (Wild, 1970, 135): for example, four long-handled combs of bone or horn used for weaving and associated with Late Celtic design[1] as well as a pair of shears were found at Newstead (Curle, 1911, 290-1).

Given the amount of cattle bones recovered, the forts would have had available huge quantities of leather for tents,[2] armour (shield covers, straps), saddles, bridles, bags, purses, cases, and clothes (shoes, belts, straps). The manufacture of these items could have been carried out in civilian settlements adjacent to forts or further afield, or in fort workshops.

Transportation of supplies from local Romano-British settlements to Roman forts likely would have followed traditional trackways, perhaps modified to link with Roman forts. An example of such a road is that

---

[1] These combs are a common occurrence among the brochs of Northern Scotland (Wild, 1979).
[2] According to Hyginus, each century would have possessed six tents, totalling 36 for an auxiliary unit, with 38 calf hides per tent (Breeze, 1984, 272).

beyond the Knag Burn Gate at Housesteads.[1] Although ruts here and in the north gate of the fort attest to wheeled traffic passing through the Wall, the gate does not open onto a known Roman road, so that traffic must have followed or linked with a native trackway.

Such native trackways are attested across Area 3. Gates (1981, 30) has identified walled trackways integrated into Iron Age field lay-outs at Coldberry hill, Brands Hill North, Hunterheugh Crags, and the Butts in Northumberland. In addition, fragmentary trackways have been recorded near Romano-British settlements in Northumberland at Greaves Ash (NT 966 163), Lordenshaws (NZ 055 992), Monday Cleugh (NT 960 286), Quarry House (NY 966 806), and to the east of Yeavering Bell (ibid.). Because gateways leading from these trackways into fields are uncommon, and because single trackways usually run in direct lines from settlements or adjacent enclosures to the outer margin of surrounding fields, "their primary purpose must have been to allow unrestricted movement between settlements and unenclosed ground beyond their fields" (ibid.). Ancient trackways may have linked Romano-British settlements not only with each other, but with Roman forts.

---

[1] This gate is a single passageway gate situated east of the east gate of the fort. It has arches at the front and rear (unlike milecastle and fort gates), and is flanked by two towers entered by doorways off the roadway (Crow, 1989).

Forests, Quarries, Mines. Timber would have been required as fuel and for construction of forts, fortlets, watch towers, signal stations, and frontier lines. Evidence discussed above (2.1.2) for high levels of clearance in the Romano-British period may in part be attributed to the Roman army's voracious appetite for timber supplies. Whether from territoria or further afield, the military is likely to have satisfied its timber requirements from within the region (Hanson, 1982).

As roads must ascend the largest hills in Area 2, it is here that overland transportation of building stone may have been most difficult. In agreement with Vitruvius,[1] evidence suggests that local stone was used in this area. Soldiers' inscriptions attest to numerous Roman period quarries along the Wall (Daniels, 1978, 42-3).[2] Throughout the central sector, either uninscribed ancient quarries or outcrops within a kilometre of the Wall may have been used to build the Curtain or Wall structures. In addition, other quarries, used throughout the ages, may have been used in the Roman period. Where urban development has not obscured the existence of old quarries, it seems that the furthest a Wall fort was situated from either a known Roman or later period quarry was 1.6km.[3]

---

[1] Vitruvius (De Arch, i.5.8) writes that legionary lapidarii generally used available local stone when selecting material to build forts and military installations.

[2] For example, the unit name is given near Haltwhistle Burn fortlet (RIB 1680), while marks of possession are given at Fallowfield Fell (RIB 1016) (Davies, 1968, 22).

[3] Rudchester sits next to a quarry; Halton Chesters: 1.6km; Corbridge: 1.3km; Chesters; 1.6km (known quarry); Carrawburgh: 1km; Housesteads: .8km, or 2km (known quarry at Black Pastures); Vindolanda: 1.2km; Great

As for quern stones, Mayen stones imported from the Rhineland were being replaced perhaps by the late 1st century AD with quern stones produced within the North-east from local millstone grit and granite (Welfare, 1985, 157). Indeed, a petrological analysis at Vindolanda has shown that all of the quern stones, apart from the Mayen stones and one other, were produced in the vicinity of the fort (ibid.).

The short distances involved in the collection of stone for construction, quern stones, or of loose rubble as attested by a Vindolanda writing tablet (Doc. 1; Inv. 195, 198; Layer 10; Bowman and Thomas, 1983, 79), could have been covered quickly and easily by ox-carts carrying 1100kg each.

Metals, especially iron and lead, would have been necessary for the construction of the many military buildings in the North-east. A vast amount of iron would have been required for nails, hinges, and locks necessary in construction. As the Romano-British shaft furnace continued in use throughout the Medieval period, it is difficult to differentiate between Roman and post-Roman period furnaces.[1] However, many iron deposits exist across the North-east and most probably would have been

---

[3] (cont'd)Chesters: 1.2km.

[1] A different type of Roman furnace has been found at Laxton, Northamptonshire. While the maximum diameter of the shaft furnace is .5m, these furnaces have a diameter of 1-1.4m (Jackson and Tylecote, 1988). However, these latter furnaces have not been attested anywhere else in the Empire, and so must be considered exceptional.

mined in the Roman period. Iron furnaces have been found at Catcote civilian settlement (Long, 1984, 20-21), while iron slag has been recovered in Chester-le-Street (Salway, 1965, 26). In addition, deposits heavily-mined along the Tyne valley in the Medieval period (see Bywell below), as well as those in Redesdale, probably would not have escaped the notice of the army garrisoned along the river for 300 years.[1] Indeed, across Britain, large quantities of discarded scrap metal found on post-Conquest sites prove that iron requirements of auxiliary forts, amounting to several tons (Manning, 1979, 116), were satisfied. In fact, small pieces rarely were re-forged, suggesting that ample supply had kept the cost of iron very low.

Lead would have been required for bath buildings, the disposal of waste products from the forts, and sometimes for the distribution of drinking water. As discussed, a Vindolanda writing tablet (Doc. 1; Inv. 195, 198; Layer 10) attests to the acquisition of lead (Bowman and Thomas, 1983, 79), and the establishment of a fort at Whitley Castle in Area 1 may have been to facilitate lead extraction from the Alston Massif (Bennett, 1990). Indeed, a Flavian period lead pig from Strageath is thought to have been mined at Alston (Frere and Wilkes, 1989, 175). In addition, orefields of Yorkshire would have been exploited as soon as the area had come under Roman control (Manning, 1979, 114). In total, the army's metal requirements were likely met by local extraction.

---

[1] For such localized exploitation of iron in Roman period Lancashire, see Penney, 1983, 60.

6.2.4 Discussion

In short, supplies could have been transported remarkably efficiently over the road system in the North-east. Those items which were shipped from long distances away to ports near the North-east could have been delivered to forts in the region quickly, depending on the nature of supplies and the port at which they were delivered. Forts in all three areas were probably supplied before the mid-Antonine period for the most part by York, while the Stanegate and Wall forts west of Corbridge were supplied from a West Coast port, and forts in Area 3 for a short period possibly from Berwick-upon-Tweed. Items which necessitated transport by ox-cart, such as grain, nails, and quern stones, would soon have been supplied for the most part on a local level, while compact Baetican amphorae may not have required many cart-loads. After the mid-Antonine period, bulky, heavy and/or awkward material could have been transported by ox-carts from South Shields or a holding depot in two days. All other material could have been transported by quick and cost-efficient pack animals to any fort in the North-east from South Shields in two days.

Bulky supplies produced in South Britain most likely would have been transported to the nearest port and shipped to the North-east. All other items, with the exception of coarse-ware pottery, could have been transported easily by pack animals over the excellent Roman road system from various areas of southern Britain.

As discussed in Appendix H, for about one hundred years (ca 100-200), the North-east may have nearly satisfied the most important, as well as the bulkiest supply demanded by the army - grain. Other supplies could have been produced or obtained from the North-east shortly after the Conquest to the end of the Roman period. These include meat and agricultural products, draught animals, textiles, leather, timber, building stone, quern stones, lead and iron. All of these items could have been transported to forts either along Roman roads, or native trackways linking settlements to each other and to Roman forts, within a short time period and with little difficulty or expense.

6.3 RIVER TRANSPORT

Rather than to facilitate river-borne supply, forts at Piercebridge, Binchester, Chester-le-Street, Ebchester, Lanchester in Area 1, Corbridge and Chesters in Area 2, and Risingham, Blakehope and High Rochester in Area 3 were constructed to protect strategic river crossings of the all important road system.

Originally, fords would have been sought by an army on campaign before a bridge was constructed. A fort garrison would have protected this vulnerable crossing, the weak link in a communication/transportation system. A fort was constructed near the best crossing point or ford, often at a bend in the river, on level ground above the flood-plain.

As mentioned, the course of Dere Street suggests that this may have been the original route of penetration into all three areas of the North-east. By following the Pennine Spurs in Area 1 rather than the relatively flatter ground to the east, not only did the route afford defensible fort sites, it avoided the broad reaches of the river courses further to the east, so that the Wear, Browney, and Derwent could be crossed over relatively accommodating fords (Steer, 1938, 45). Indeed, across the Empire, crossings were often chosen near the head of a river before the valley deepened and widened (Chevalier, 1976, 197). Dere Street in Area 2 crosses the Tyne at Corbridge at the most favourable crossing, as indicated by the western kink in the road as it approaches the Tyne's south bank. Eventually, the Flavian site at Red House was given up in favour of a new site directly overlooking the crossing, and site of the later stone bridge. In Area 3, Dere Street penetrates the high ground of the Cheviot foothills through the Rede valley. At Risingham, Dere Street may have crossed the broad Rede flood-plain over a ford long before the stone bridge was built, and construction of the Antonine stone fort at this site may have been to protect a new stone bridge constructed over the ford. Constructed as close to the bridge site above the flood plain as possible,[1] the fort is completely exposed to the north wind prevailing south down the Rede valley. Although more protected sites abound in the area, it seems insulation from the elements was less a priority than proximity to the bridge below.

---

[1] As discussed (5.1.2), this is suggested by the eventual scouring of the north face of the fort's platform.

After a bridge had been constructed over or near a crossing, a nearby fort garrison would have continued to be important for protecting the bridge against destruction not only by the 'enemy', but also by natural forces. First, if unattended, river-borne debris, especially logs and brush, would have collected between the piers: within a few seasons, the pressure exerted from this blockage would have damaged the piers (Margary, 1948). Second, flood-waters in rivers of the North-east would have played havoc upon bridge infrastructures. Fast-flowing waters would have undermined the area behind the piers, where eddies of water would have scoured the river bed. This action would have undermined the piers' foundations, rendering them vulnerable to the river's current.

Piercebridge is a case in point: the first bridge, likely situated over Dere Street's original crossing point, was constructed where the Tees emerges onto low ground from a highland tract of two closely-set banks.[1] However, if suitable for a crossing, the bridge on this site would have been exposed to the full force of the notorious North-eastern flood-waters rushing through the steep banks. By the end of the 2nd century, a second bridge was constructed further downriver at a point where the force of flood-waters cascading through the 'chute' of steep banks had somewhat dissipated over a wider, shallower course.

---

[1] Chevalier argues (1976, 197) that constructing a fort at the interface between lowland and highland areas was common throughout the Empire, as such a position would facilitate the control over movement and exchange between regions with different and complimentary soils and production.

Apart from Vindolanda along the Stanegate, and Corbridge mentioned above, the remaining forts in Area 2 were integrated into the overall construction and strategy of the Hadrianic Wall system. As the Stanegate west of the North Tyne is located north of the South Tyne, and because Hadrian's Wall was constructed north of the Stanegate, these forts are well away from a river. For reasons of strategy, Hadrian's Wall east of the North Tyne runs not only north of the Stanegate, but also north of the Tyne.[1] As the north bank rises quickly from the Tyne, the closest point to the river over which the Wall system could have been constructed was along the northern lip of the Tyne valley. Therefore, although Wallsend, Newcastle, and Benwell were positioned relatively close to the Tyne, because of the southward curve of the river, Rudchester and Halton Chesters lie some distance away from the river to the north.

Even if some Hadrianic Wall forts were constructed near the river, again it was for reasons of strategy rather than river-borne supply. Constructed on the right bank of the North Tyne, Chesters guarded the crossing of the Wall and eventually the Military Way. Constructed before forts at Newcastle and Wallsend, Benwell fort initially may have had an important position as the easternmost Wall fort: indeed, it is situated

---

[1] If it had been constructed along the Stanegate on the south bank, the Tyne itself would have created a barrier to forward movement to the north, and it was to the north that the army was meant to meet the enemy. This is suggested by the proliferation of gates in milecastles and forts opening through the Wall, predominance of cavalry (such as that at Chesters: Austen and Breeze, 1979), and part-mounted equitate units along the Wall in the east (see Appendix A).

on top of a large hill[1] overlooking the end of the Wall to the east, and Denton Burn to the west. The fort at Newcastle was constructed at least in part to guard the stone bridge linking the eastern end of the Wall with the road system on the south bank of the Tyne. Wallsend, constructed when the forts were moved to the Wall line and at the same time as the extension of the Wall east from Newcastle,[2] guarded the denes between Wallsend and Newcastle (Daniels, 1978, 57) as well as the marshy inlets characterizing the lower Tyne until the 19th century dredging operations, and provided cover and patrol of the native settlements of the Blyth Valley (Bennett, 1990, 541).

However, although forts in the North-east were constructed along rivers for reasons of strategy rather than river-borne supply, once constructed, a certain amount of river-borne supply may have been carried out.

---

[1] The Latin name of this fort is thought to be Condercum, or literally, 'the place with the fine outlook'.
[2] Evidence for this is the regular spacing between Benwell and Wallsend, its three gates opening north of the Wall, and the contemporaneity of the fort gateway with the narrow gauge phase of Wall (Daniels, 1978, 57).

6.3.1 Navigation below the tidal limits

Until the advent of the Canal Age ca 1760 (Willan, 1964, 6), the cheapest and most convenient form of commercial transport within Britain was along navigable rivers. Along the larger waterways, such as the Yorkshire Ouse, Trent, Severn and Thames and many East Anglian rivers, ships were often able to penetrate for a considerable distance into interior Britain (see Porteous, 1977, 8). This also seems to have been the case in Roman Britain.

Evidence suggests that a main consideration for the siting of legionary fortresses in Britain was that they might be supplied by ocean-going ships. Indeed, the fortresses which later became permanent bases - Chester, Caerleon, and York - were sited near or at the tidal limits of their respective rivers which discharge into the sea (Pitts and St Joseph, 1985, 44).[1] This position allowed river-borne transport of sea-borne supplies not only to the fortresses but also to the surrounding areas. Indeed, across the Empire settlements often prospered at the furthest navigable point along a river, after which supplies were

---

[1] At Chester, a quay wall 2.45m thick and 225m long, a timber wharf, and warehouses east of the quay wall strongly suggest that the fort was serviced by ocean-going ships plying the Dee (Thompson, 1965, 46); at Caerleon, what is considered imported grain has been recovered, suggesting sea-borne supply along the River Usk (Helbaek, 1964, 158-64); at York, in addition to the dedication by the pilot described above (6.2.1), a massive stone platform on the bank and a double row of piles in the river-bed probably represent a wharf serving the fortress (Liversidge, 1968, 405).

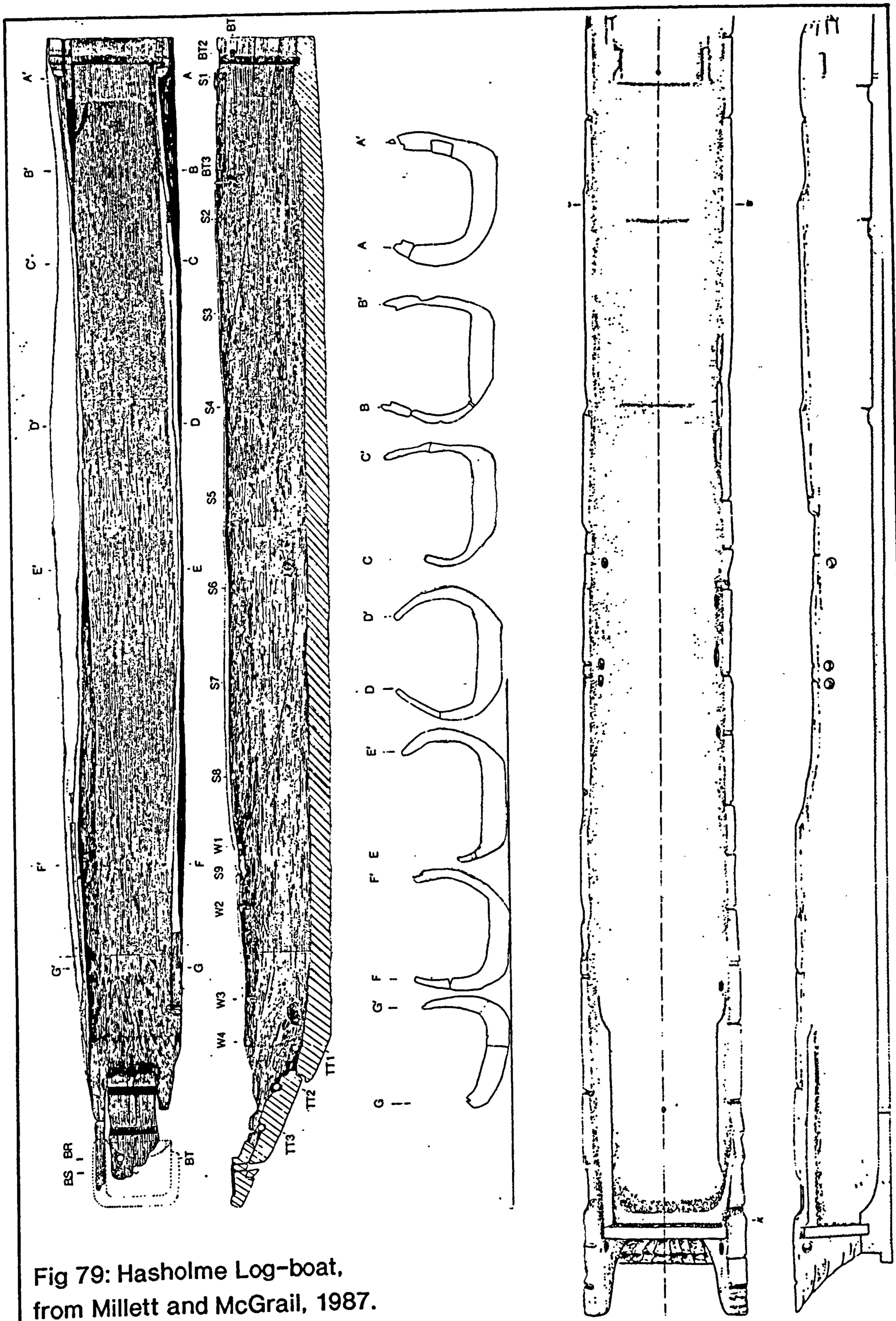


Fig 79: Hasholme Log-boat,
from Millett and McGrail, 1987.

Fig 80: Brigg Log-boat, from McGrail, 1978.

trans-shipped along the road system (Chevalier, 1976, 198).[1]

Medium-sized boats

Perhaps the best example for the use of medium-sized boats in Britain for supply along rivers in the Roman period is the Hasholme log-boat. Recovered during drainage works in 1984 ca 3km up the Old River Ancholme from its confluence with the Humber, this craft has been dated by dendrochronology to the 2nd century BC (Millett and McGrail, 1987; see figure 79). Made from a single log, flat-bottomed with rounded and extended bow, fitted transom stern, and additional wash-strake, the boat is both large and sophisticated.[2] At 12.78m long, with a maximum beam of 1.4m, and 1.25m high, the Hasholme log-boat was capable of carrying ca 8,902kg of cargo with a crew of five men (ibid., 134). Animals represented by bone recovery[3] as well as a number of timber fragments suggests that the barge may have been used for the distribution of commodities within a local system of exchange in the area (ibid., 147).

---

[1] A fine example of such is Roanne along the Loire, at which point river-borne supplies were transferred onto carts and carried overland to Lyons (Chevalier, 1976, 198).

[2] The beam-ties and wash-strakes, treenails to fasten planking and other fittings, the design and fashioning of the bow elements, and the fitting of a dove-tail-shaped repair are the first known in North-west Europe, while the use of keys or cotters to lock fastenings is unknown before the Viking Age (Millett and McGrail, 1987).

[3] From a total of 216 animal bone fragments found around the boat, most were cattle, the rest sheep, horse and red deer.

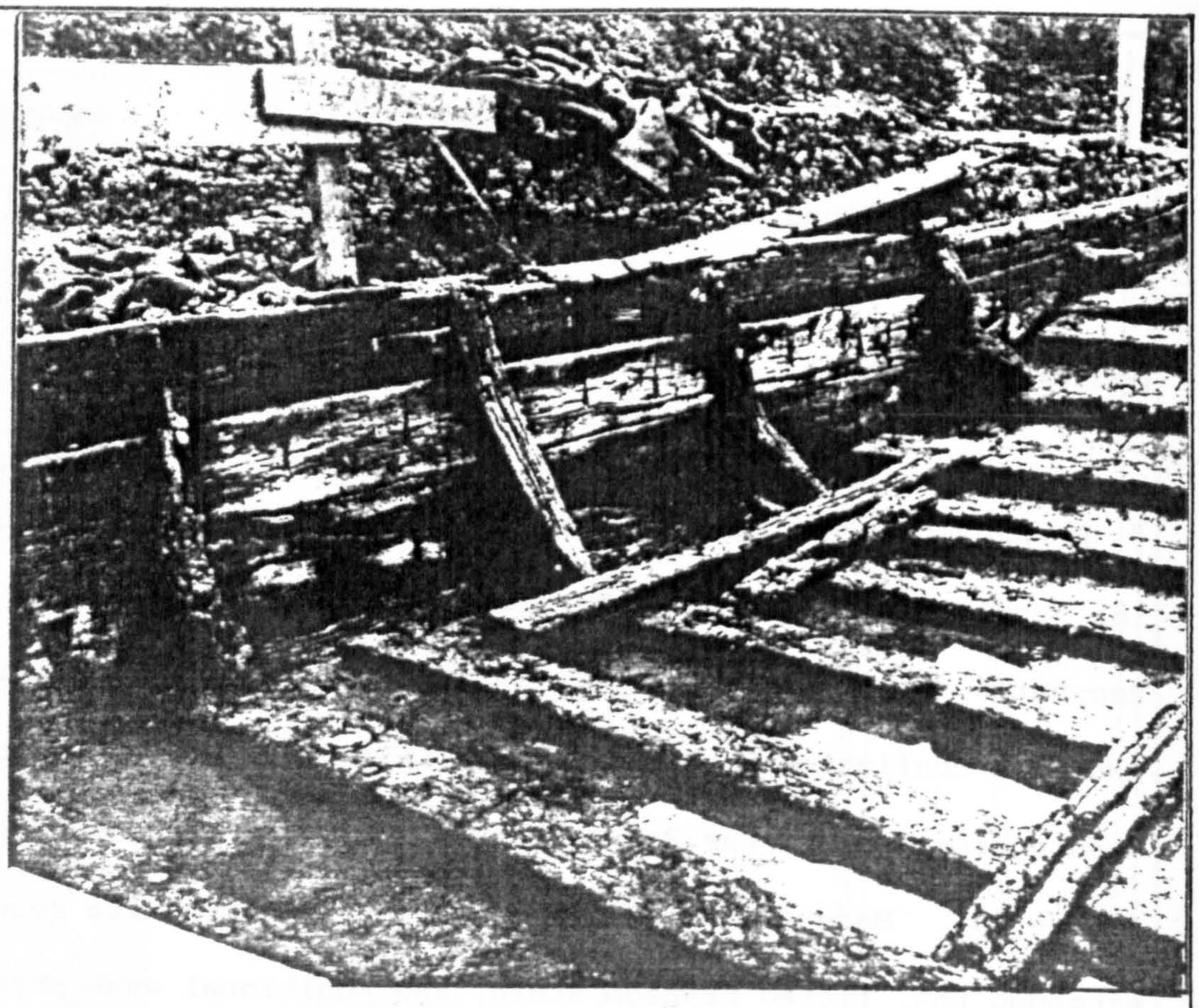
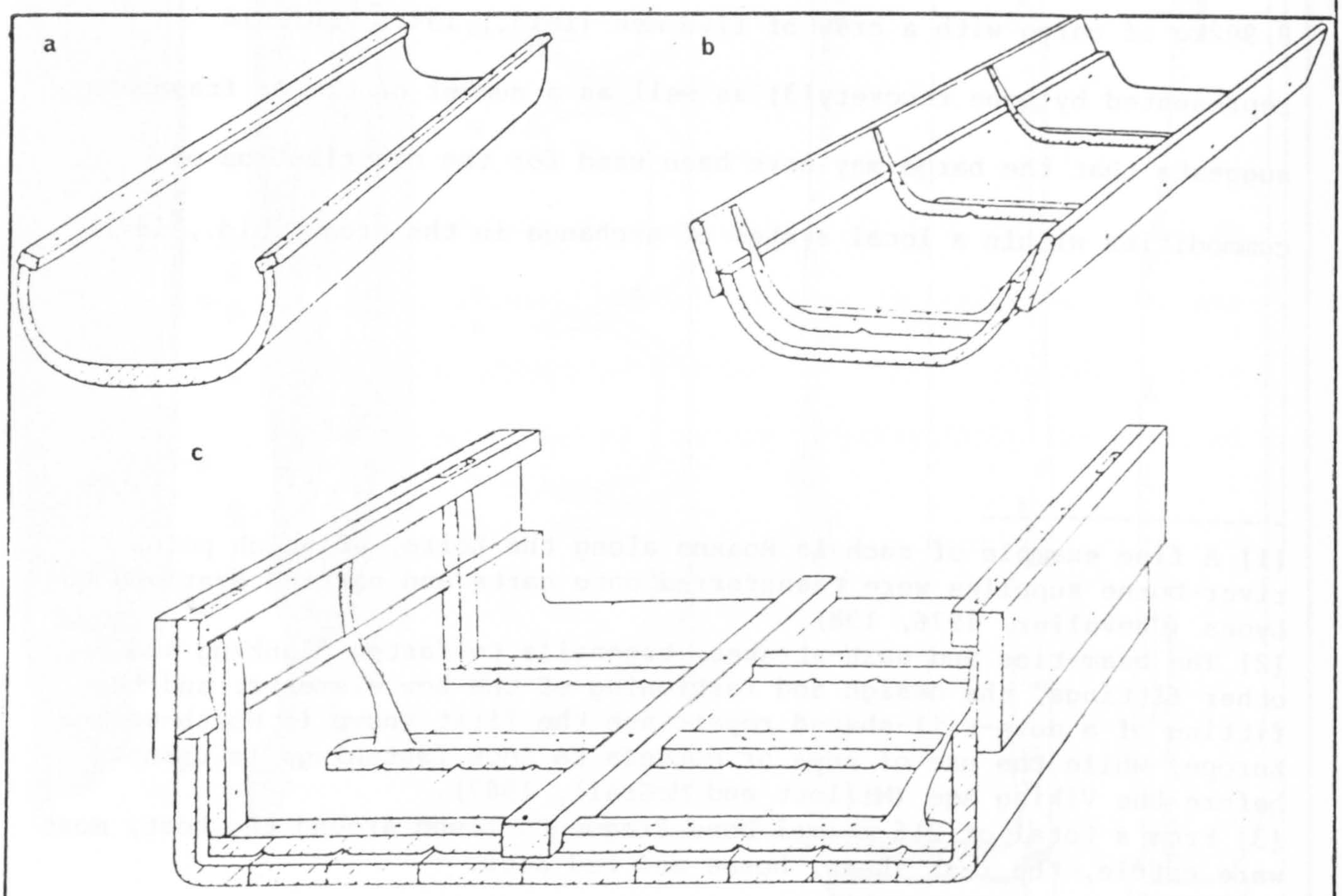


Plate 57: Zwammerdam 6, after de Weerd, 1978



Sections of (a) the simple dugout Zwammerdam 1, (b) the heightened dugout Zwammerdam 3, and (c) the barge Zwammerdam 2. A single dugout can be heightened, and a heightened dugout can be longitudinally split with the intention of placing strakes between the resulting dugout chines (drawings IPP: B Donker)

Fig 81: The evolution of the dug-out, or log-boat.
After de Weerd, 1978.

Other such log-boats used for the supply of Roman forts have been recovered on the Continent. Below a three-period Roman auxiliary fort near Zwammerdam, Holland, excavations in 1971 on the north bank of the Rhine revealed three dug-outs, three barges made from dug-outs, and one steering oar, all dated AD 150-225 (see plate 57; de Weerd, 1978, 15-21). At Pommeroeul, Belgium, the excavation of a canal in 1975 revealed a previously unknown Roman village, with five Roman period boats of the second half of the 1st or early 2nd century AD (de Boe, 1978, 22-30; see plates 61, 62). The boats comprised two dug-outs, two flat-bottomed barges, and one of an unknown type. At Bevaix and Yverdon in Switzerland, excavations on the bed of Lake Neuchâtel in 1971-2 uncovered two Celtic boats of the Roman period (Arnold, 1978, 34). Most of these boats are very large (Zwammerdam 4 is 34m long; de Weerd, 1978, 17), were undoubtedly cargo carriers (one of the canoes at Pommeroeul was completely filled with pottery; de Boe, 1978), and may even have been enlarged to meet the demands of the Roman army (see figure 81).[1]

---

[1] The barges at Zwammerdam, Kapel Avezaath, and Druten only came into use after AD 150, a period of unrest outside the limes of Lower Germany. The Roman military administration needed a transport system in order to rebuild in stone the old wooden forts, and may have had many of these large transports built together in southern Germany (as suggested by pollen analysis of the Zwammerdam boats (de Weerd, 1978, 16). Construction of these large boats most likely represents a Romanization of local pre-Roman traditions: "the construction is native in origin, but the size is Roman" (de Weerd, 1978).

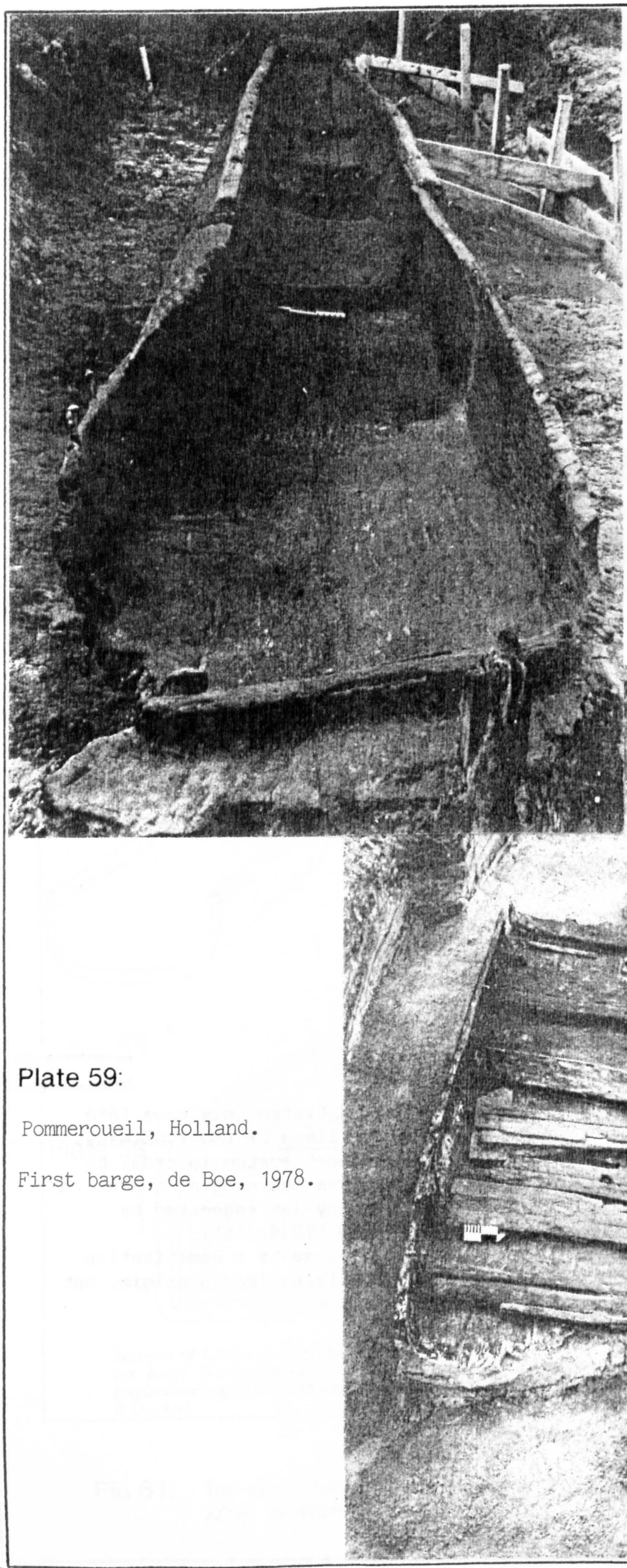


Plate 58:

Pommeroueil, Holland.

Second Canoe,

de Boe, 1978.

Plate 59:

Pommeroueil, Holland.

First barge, de Boe, 1978.

Logistics in the North-east

However, certain factors would have impeded navigation of ships or medium-sized boats below the tidal limits of North-eastern rivers. First, the rivers of the North-east are much smaller than the Humber, Ouse, Dee, and Rhine. Indeed, after leaving the Humber, the Hasholme log-boat ran aground 3km along the much smaller Old River Ancholme, at which point it was abandoned (pers comm Martin Millett). Second, as discussed above (2.1.1; 2.1.2), Roman period sea and river levels were lower. Sea levels lower by as much as 3m would not only have decreased river depths within the tidal limit, but would have shortened the tidal limits themselves by a significant margin. Above the tidal limits, lower river levels due to the climate, exacerbating an already high concentration of sediment load due to cultivation and clearance, would have created conditions of high alluviation. When combined with the propensity for tidal waters to discharge their sediment loads before the ebb tide, the rivers of the North-east in the Roman period would have been very prone to siltation, so that sand bars and shoals would have proliferated below the tidal limits.

Area 1. The only fort in Area 1 which lies within or near the tidal limit is Chester-le-Street on the Wear. Evidence suggests that 19th century Wear boats, able to carry 9,080kg (Kirby, 1972) and comparable in carrying capacity to the Hasholme log-boat at 8,902kg, had much difficulty navigating the Wear within the tidal limits. The river often was very shallow: at Forsters Sands downriver from Chester-le-Street, the river was only 22.5cm deep at periods of low tide in dry weather, and neap tides only swelled the depth to 50cm, so that bargemen sometimes had to wait five or six days for sufficient draught (Kirby, 1972, 264). Therefore, if medium-sized boats were difficult to navigate as far as the tidal limit in the modern period, it is likely that Roman period bargemen would have had at least as much, if not a great deal more difficulty navigating craft of the same size from Wearmouth to Chester-le-Street. Ships could not have managed the journey.

Area 2. In addition to South Shields, Wallsend, Newcastle, and possibly Benwell[1] were positioned within the tidal limit of the Tyne.

Wallsend. On the basis of evidence suggesting a Roman period quay below Wallsend fort (discussed above, 4.1.1), it has been suggested (Cleere, 1978, 37) that Wallsend may have been the permanent harbour for supplying the Wall forts. Unfortunately, 19th century dredging operations removed the last traces of this structure, so that it is not

---

[1] Although modern tidal limits are at Stella, near Rudchester, Roman period tidal limits would have been much lower, although perhaps not lower than Benwell, ca 4km downriver from Stella.

possible to determine its character. Nevertheless, it is now to consider the possibilities that it received ships or medium-sized boats.

Ships. Even if this structure was a Roman period quay, it is unlikely to have received round or even flat-bottomed ships navigating the Tyne on a large scale. Again, conditions would have been worse in the Roman than modern period, and navigation before late 19th century dredging operations of the Tyne was notoriously difficult. Indeed:

> "[The Tyne] was a tortuous, shallow stream, full of sandbanks and eccentric eddies, [it] twisted, turned, and expanded, or rushing with impetuous haste ... the waterway was contracted and dangerous, and only navigable with great difficulty for a few miles from the sea...there are still living men who recount their fording of the river below Newcastle, who played truant from school to "plodge" across to the King's Meadows and there hold high revelry, who tell of small schooners and brigs lying aground at the Quay, of women with skirts kilted up gathering coals in the bed of the river."
>
> Johnson, 1895, 9-10

At Newcastle, vessels of moderate size and draught were sometimes detained for weeks after loading, unable to get to sea at the top of high water. In 1849, a hundred-ton schooner was stranded on a sandbank for weeks below Newcastle, while at the same time, the Norval was grounded at Hebburn Sand 7km downriver from Newcastle (Johnson, 1895, 10). Indeed, a trip down the Tyne was "an enterprise full of eventualities, not to be hazarded by persons of weak nerves or timorous temperament" (ibid., 13). Some of the problems encountered whilst navigating from Newcastle to South Shields are demonstrated by the voyage of the Conside in the same year.

".. the Conside was partly laden, and appeared then to have drawn about nine feet water. She first grounded at the low part of Newcastle Quay, and lay there half an hour; she then stuck fast on Tyne Main shoal at one mile and a quarter below the bridge; got clear across Hebburn shoal by giving her full speed over the ground, but in doing so sunk a craft, and went against a lighter and sunk her also; then she went to sea."

Johnson, 1895, 10

Medium-sized boats. As for navigation of medium-sized boats, it has been argued in the past (see Richmond, 1953) that supplies may have been transported from South Shields along the river in the Roman period as was done by the Keelmen of the modern period.[1]

It may well be that some of the supplies shipped to South Shields were transported by barges similar to the Hasholme log-boat to the quay at Wallsend. However, it is unlikely that a large-scale supply system for forts east of Portgate devolved upon a barge passage from South Shields to Wallsend quay. Indeed, such a barge passage would have increased the chances of damage or loss of the supplies. First, shoals, bars, currents, tides, and winds would have made such a navigation risky, and the risk would have been magnified if transport was carried out on a large-scale. Second, once coasters had grounded on the beaches at South Shields, a barge passage to Wallsend would have required an extra stage of trans-shipment. Rather than transferring the cargo directly onto pack

---

[1] As discussed in Appendix L-3, Keelmen transported coal from collieries along the banks from Stella, at the furthest, down the Tyne to boats waiting at the river's mouth, into which the coals were directly trans-shipped.

animals or ox-carts at South Shields for delivery over the road system to the forts, a barge passage would have required loading the barges, and then trans-shipping the cargo again onto pack animals and/or carts at Wallsend. Third, during the Hadrianic period, many of the supplies which could have been barged were valuable or contained valuable items, such as samian ware, precious metals, textiles, glass, medicines, mirrors, luxury foods, amphorae and barrels. As both the passage itself and an extra stage of trans-shipment would have increased the risks of damage or loss of these valuable supplies, barge supply to Wallsend more likely would have been limited to the fort itself, or to its adjacent settlement.

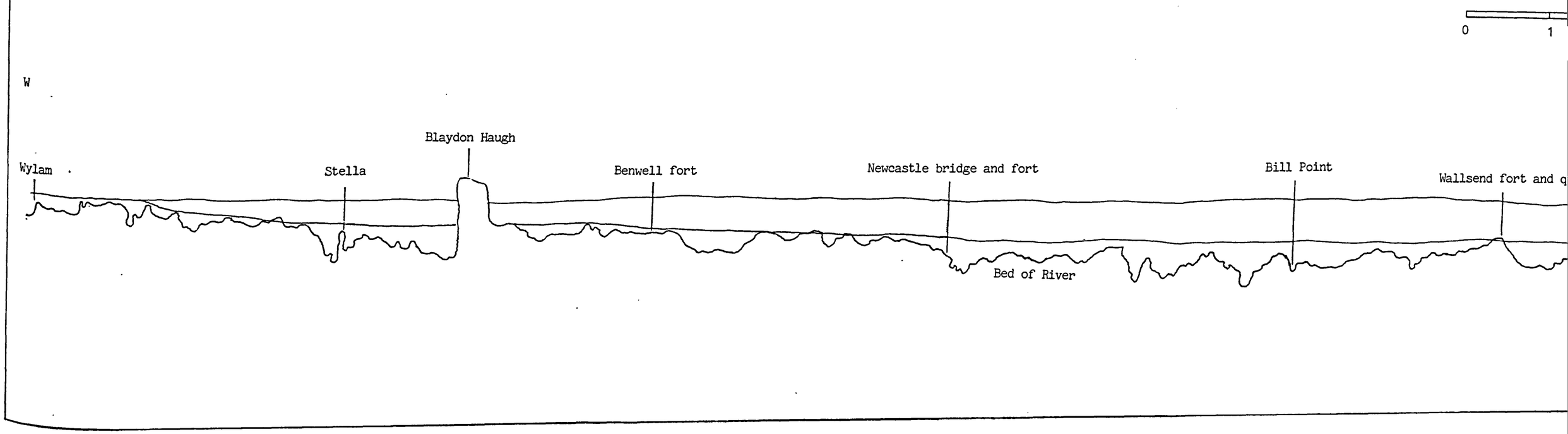
Indeed, the Antonine period construction of a fort at South Shields, stone bridge at Newcastle, and Military Way behind the Wall, suggests strongly that supply to forts in Areas 2 and 3 devolved mainly upon overland transport from the fort at South Shields. Such a system would have provided for much safer transport of grain from the storage facilities at South Shields to forts in the North-east than a barge passage to Wallsend.

Benwell. Evidence for sea-borne supply to Benwell is as follows. An inscription (RIB 1340) attests to the Classis Britannica building at Benwell,[1] a monumental gate and Hadrianic causeway[2] over the vallum

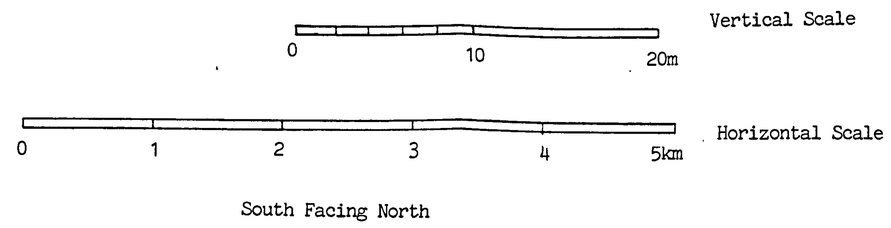
---

[1] The inscription records construction by a detachment of the fleet in Britain, under Aulus Platorius Nepos, 122-6.
[2] Six periods of road have been found passing over the Hadrianic causeway and vallum south of Benwell fort (Salway, 1965, 71).

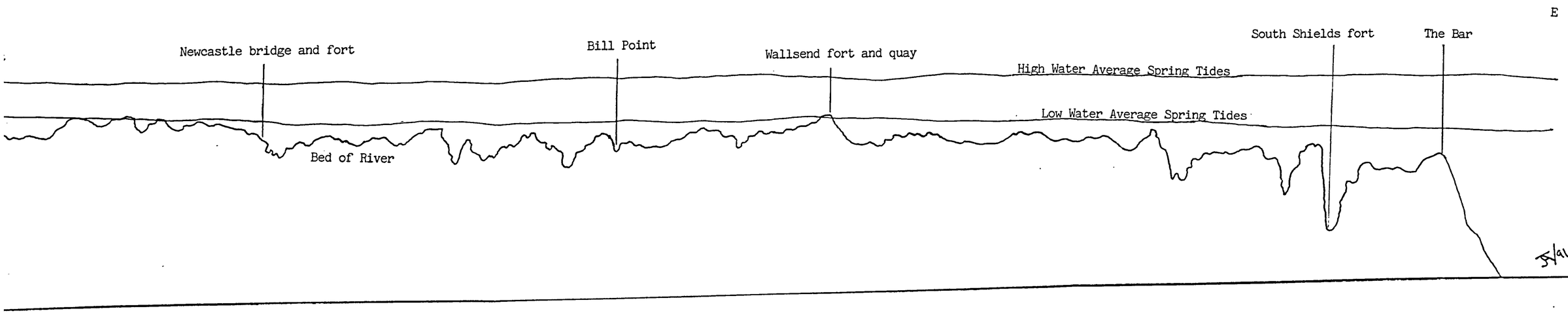
Fig. 82 Longitudinal section on the centre line of the River Tyne from the sea to Wylam: showing the depth of channel and the lines of high and low water spring tides in 1860, from the surveys of J F Ure and P J Messent, in Johnson, 1895.



sea to Wylam:
pring tides in 1860,



South Facing North



suggests a road running down to the river, a larger than normal granary suggests a 'holding depot', and Benwell would have been for a time the closest Wall fort to the North Sea. In addition, a possible trading connection between South Shields and Benwell is suggested by a tombstone inscription (RIB 1064) set up to the freedman Victor living in Benwell by his master Numerianus, a soldier of ala I Asturum at South Shields, sometime in the late 2nd, or 3rd century (Collingwood and Wright, 1965). This tombstone seems to describe the elevation of Victor to perhaps a partner in business with Numerianus.[1]

However, this evidence is circumstantial: the inscription recording construction by sailors of the Classis Britannica suggests merely that they were present at the site, not that they had navigated to Benwell. On the basis of the great difficulties in navigating the Tyne to this point in anything but a very small vessel in the Roman period, the large granary, monumental south gate, and inscription suggesting a trade link most likely belong to the context of the road system running east-west, rather than to river transport. Indeed, as shown on figure 82, low tides in 1860 at Benwell barely covered the main channel, and at high tide the river was less than 3m deep. Again, lower sea levels and higher alluviation rates in the Roman period would have rendered navigation of this channel impossible even by flat-bottomed ships, and exceedingly difficult, dangerous, and time-consuming for medium-sized boats.

---

[1] The elaborate nature of the tombstone has been argued to denote that Victor had been the natural son of Numerianus by a slave concubine (Bidwell and Speak, forthcoming, 13).

Area 3. All of the forts in Area 3 lie beyond the tidal limits of their respective rivers, and will be discussed below.

6.3.2 Navigation above the tidal limits

As for the area above the tidal limits, navigation most likely would have been limited. As discussed, no evidence exists for construction of artificial water-raising devices along these rivers in the Roman period. However, this much of the Piercebridge formula is sound: these rivers would have needed artificial devices to raise their levels to allow unrestricted navigation. A walk along the rivers of this survey area during the low spate of the summer months is enough to demonstrate the futility of attempting to navigate many stretches of these rivers, which are often no more than streams, and their requisite shoals and rapids, in their natural state. Lower Roman period river levels and high alluviation rates would have rendered impossible the navigation of these rivers over anything but short stretches in the summer months. As for the winter months, problems of river levels and alluviation impeding navigation would have been compounded by tempestuous flooding of the river systems. Therefore, a river supply system originating at river mouths and terminating at the requisite forts did not operate in the Roman period.

However, it is possible that the rivers were used on a local level when naturally navigable. Small rather than medium-sized boats may have been used above the tidal limits: indeed, smaller craft may not have

suffered the fate of the medium-sized Hasholme log-boat, which, having run aground, was left to rot (pers comm Martin Millett).

Small Boats

Two artefacts suggest the use of a river craft at the Roman fort of Newstead-on-Tweed, just to the north of Area 3. A steering oar was found standing upright in the corner of Pit LXV (Curle, 1911, 313; see figure 83). Curle argues that the oar was used at the side of a low-freeboard, high stern-posted boat. Measuring 1.62m long, its loom is 17.5cm in circumference, and the blade 13.75cm in width. A hole, 12.5cm from the top, 3.27cm sq and cut through the shaft, may have contained a tiller, another hole at the blade's bottom may have held a cord attaching blade to gunwale to allow the oar to be moved laterally, and some kind of collar or grummet may have held the loom against the gunwale, allowing the oar to be rotated. In addition, a piece of iron recovered from the ditch of the later fort may have been either a boat hook, or a device for pulling up buckets from the bottom of a well (Curle, 1911, 288; see figure 84).

Elsewhere, a native dug-out recovered in 1964 on the River Arun at Hardham, Sussex, and radio-carbon dated to AD 295 +/-50 is considered a cargo barge (McGrail, 1978, 203). Hardham 2 was constructed from a hollowed-out log, with ends bluntly-rounded in plan and slightly inclined in elevation, and measuring 3.89m in length. Near a ridge along the bottom are two treenails 50mm long thought to be thole pins, suggesting

Fig 83: Steering oar found in Pit LXV at Newstead Roman fort. 1.62m long (plate LXVI, Curle, 1911).

Fig 84: A large piece of iron recovered from ditch of later fort. This piece is thought to be a boat hook. (plate LXIX, Curle, 1911).

the barge was powered by a sculling oar (ibid.).

Curraghs may have been used in the North-east as cargo carriers. Before the Conquest, Caesar alludes to their use[1] by native Britons during his invasions of BC 55 and BC 54. In the Civil War, Caesar was able to extricate himself from a difficult position in Spain by ordering his troops to make curraghs like those he had seen in Britain some years before.[2]

> "... the keels and ribs were made of light timber, the rest of the bulk of the ships was wrought with wicker-work and covered over with hides. When these were finished, he drew them down to the river in wagons in one night, a distance of twenty-two miles from his camp."
>
> Caesar B Civ. 1.54

Two boats identified on Romano-British coins from the quinarius issue of Allectus (late 3rd century) may represent a local British craft used by the Roman fleet (Johnstone, 1980, 151) on small rivers. They depict a small rowing boat with a steersman, four crew and no mast (ibid.). These coins differ from other Allectus coins which depict much larger Roman warships, with masts, oars, rams and stern shelters (ibid.).

Finally, although nothing remains, it is conceivable that rafts would have been used for transporting cargo in the Roman period.

---

[1] The size and the fact that they could be rowed suggests that the boats were curraghs rather than coracles.
[2] Using this craft, he was able to cross the river Sicoris near Lerida, when his enemies thought he was contained by its flood-waters.

Logistics in the North-east

Once obstacles had rendered the river course in its natural state unnavigable, various methods may have been employed to facilitate continued transportation. First, as discussed in Appendix K-1, Eckholdt (1984) has suggested that rivers in Central Europe could have been improved to a certain extent. In order to render rivers navigable, channels could have been straightened by cutting-off sinuous meanders, vegetation cleared, bars dredged, logs and boulders removed, and shallow waters deepened somewhat. Second, obstacles could have been overcome by attaching inflated goat skins to the craft's gunwales, thus decreasing the draught (see Appendix K-2). Third, as was accomplished in the ancient period along the Nile above Aswan and in the modern period by Les Voyageurs in Canada along the river systems, difficult passages could have been avoided by a portage of material and craft around the obstacles (see Appendix K-3). Finally, obstacles could have been avoided by trans-shipment from barges to overland transport.

However, as for river improvement, straightening, removing obstacles, and dredging the channel may have caused more problems than they solved. Morisawa (1985) argues that straightening a channel limits the area over which the river can be re-charged from the underlying water table during dry spells; removing vegetation causes loss of shade and protection which increases stream temperature, augments drying and evaporation and reduces transpiration, thus increases erosion and therefore sediment concentration in the river; straightening, removing vegetation and other

obstructions, or dredging shallows or bars also smooths the natural roughness of the river, resulting in increased velocity and decreased energy loss over the stretch; by thus changing the hydraulic gradient, scour is induced in bed and/or banks through the altered stretch or immediately below it, and again, erosion and sedimentation rates are increased, so that deposition occurs further downstream.

In short, any action taken upon a river regime, especially a dynamic, flood and silt-prone river, results in a compensatory reaction to maintain the balance. Straightening, removing vegetation, or dredging in the end will raise the level of sediment concentration, and thereby create new shoals and bars downriver, causing them to require attention. Therefore, if North-eastern rivers were improved to facilitate navigation in the Roman period, they most likely would have been done so only on a limited basis, rather than comprehensively over the river systems.

By the same token, very low river water levels and endemic shoals and bars would have precluded regular and unimpeded navigation of the river systems no matter how many inflated goat skins were attached to a craft's gunwales.

Furthermore, while portaging around obstacles with birch-bark canoes may have been tenable for the Ethiopians along the Nile in the ancient period, or by the Les Voyageurs of the North-west Company, it may have been much more difficult with Roman period cargo craft. The Nile and rivers navigated by Les Voyageurs for thousands of kilometres were wide

and deep, comparing poorly with the shallow and silt-prone rivers of the North-east in the Roman period, and obstacles requiring portage would have been much more numerous on North-eastern rivers. Second, while little is known of the collapsible boats of the Ethiopians, the yellow birch bark canoes of the Nor'Westers were very light and fragile (Newman, 1988, 33): on the other hand, most of the Romano-British cargo craft listed above would have been much heavier. For example, Hardham 2, a much smaller cargo-carrier, was fashioned from a single log, and would have weighed many times the weight of a canoe, so that one portage may have been extremely difficult for the Hardham 2 bargemen, if not impossible. Rafts would have become water-logged and very heavy, while at the same time awkward to handle out of water. Curraghs would have been easily portaged, but their cargo-carrying capacity cannot compare with the Hardham 2, let alone the canoes of the Nor'Westers. Therefore, regularly portaging small amounts of material may not have been deemed worth the effort.

If obstacles were avoided by the expedient of unloading barges, it is much more likely that cargo would have been trans-shipped onto carts and delivered from there to forts over the road systems. As described in detail in Appendix K-4, such a system of trans-shipment seems to have existed at Heronbridge on the River Dee. It seems that pottery and raw materials may have been supplied to Chester from Holt via river barge to Heronbridge, at which point supplies were transferred directly onto carts or pack animals for transport along Watling Street, or stored in warehouses for future overland transportation (Thompson, 1965).

As discussed above (6.2.3), the North-east was traversed by Roman trunk roads as well as native trackways. As unmetalled native tracks would have been inherently difficult to negotiate, they would have followed the gentlest terrain possible: across the North-east, the gentlest terrain follows river valleys. It is indeed conceivable that every river was accompanied perhaps on both banks by a traditional track. Therefore, once rivers became naturally unnavigable, the cargo could have been unloaded onto carts or pack animals and transported overland to a fort, as was probably done at Heronbridge. In other cases, cargo may have been unloaded onto a track, and transported to a Roman trunk road for overland delivery to a fort. This is likely to have been the case for forts west of Corbridge along the Wall in Area 2: the South Tyne could have been used for transport to a certain extent, after which supplies could have been transferred onto carts and driven eventually to the Stanegate for delivery to the forts. In addition, bargemen navigating to a certain extent the River Aln may have unloaded the cargo at the Devil's Causeway onto carts for delivery to Low Learchild.

6.3.3 Discussion

When naturally navigable, rivers would have provided a cheap and efficient mode of transport for bulk items. However, although limited supply below the tidal limits may have been carried out to Wallsend by medium-sized or smaller barges from South Shields, such supply is exceptional in the North-east. Given the conditions of rivers in the Roman period, ships or medium-sized boats would have been unable to

navigate below the tidal limits without serious difficulty. If the Tyne could have been navigated to Newcastle and Benwell with small boats or rafts, which is uncertain, the cargo-carrying capacity of such boats or rafts would have rendered such supply merely supplemental to overland supply. In short, rivers would not have been used within their tidal limits for the purpose of shortening journeys overland: the combination of shoals, tides, winds, and currents would have rendered such navigation dangerous, and together with an additional trans-shipment stage, would have increased the risks of damage or loss of supplies.

If the navigation of ships and medium-sized boats was difficult below the tidal limits, it would have been virtually impossible above the tidal limits. However, small boats may have been used on rivers above their tidal limits for transporting items cultivated, quarried, felled, mined or otherwise produced in the river valleys. Indeed, the transport of local agricultural produce, textiles, and leather from local Romano-British settlements, as well as stone, timber, and metal ores may have been accomplished by such boats as that steered by the Newstead oar, in the general vicinity of each fort. Given the problems of flooding and siltation, efforts to improve the rivers would have been in vain, so that river-borne transport above the tidal marks most likely would have been limited, and no more than supplementary to the road system.

6.4 CONCLUSION: AN ALTERNATIVE METHOD OF SUPPLY

An alternative to the Piercebridge formula method of supply to forts in the North-east combines transport by sea, roads, and naturally navigable rivers. Those materials which were imported from long distances away would have been shipped over the greater part of the journey to the North-east. Such material would have been collected at various ports along the west coast of Europe and the south coast of Britain and Thames estuary, and shipped directly or indirectly by private merchants on at least two types of ships to one of four ports serving the North-east. From the Conquest, ships would have sailed to York as well as a west coast port, and possibly Berwick-upon-Tweed before the mid-Antonine period, after which South Shields may have become the dominant port for supply to the North-east.

Only some of the items shipped to ports were bulky, heavy, and/or awkward enough to require transport by ox-cart to forts in the North-east. Even so, long distance overland supply of amphorae, barrels, pay chests, grain, and raw materials would have been sporadic. Ox-carts would have travelled over excellent roads, equipped possibly with 'holding depots', and by the mid-Antonine period, could have reached each fort in the North-east from a holding depot or from South Shields itself within two days. All other items could have been supplied quickly and cheaply by pack animals, which could have reached each fort in the North-east from South Shields within one day.

Supplies transported overland from areas south of York could have been managed by pack animals, with the exception of some cooking wares. However, many items could have been produced and supplied within the North-east after the Conquest. Some or most of the forts had 'factories' for manufacturing weapons, armour, and tools, while lands adjacent to forts or further afield provided fodder, game, and raw materials. Romano-British settlements would have been able to supply sufficient quantities of textiles, leather, meat and agricultural produce, including, for about one hundred years, grain.

Although most of the locally-produced materials would have been transported upon the very efficient Roman road or native trackway system to the forts, some may have been transported along rivers to forts when such rivers were naturally navigable. However, while each river may have been used for transportation on a local level more or less than other rivers in the North-east, the main axis of transportation would have remained the same: the bulkiest items supplied from long distances away would have been transported to forts primarily by sea and road.

In total, if transportation and communication across the Roman period North-east was not perfect, it attained levels of efficiency unrivalled before the ages of turnpikes and railways.

CHAPTER SEVEN

GENERAL CONCLUSIONS

It is very unlikely that a system of river supply such as the Piercebridge formula was used in the North-east in the Roman period. Construction and maintenance of the system over small, dynamic, and silt and flood-prone rivers, together with the unlikelihood that an efficient lifting device was known in the Roman period, would have rendered the Piercebridge formula very inefficient.

Conversely, high quality Roman roads were constructed across the North-east. Unlike the appalling road conditions which spurred improvement of rivers and construction of canals during the Industrial Revolution, Roman roads were much better designed to accommodate transportation of heavy bulk supplies, in wheeled carts or by pack animals. The abandonment of this system for the Piercebridge formula would seem reasonable only if it was significantly more efficient than overland transport. However, the inefficiencies of overland transport have been grossly exaggerated in The Piercebridge Formula: ox transport would have been at least 2.5 times more efficient in time, and would have been used for transporting only a portion of the necessary supplies. Indeed, much material could have been transported by pack animals far more quickly and inexpensively than by ox-cart.

Therefore, because the Piercebridge formula system could not have been significantly more efficient than transport over the road system, it would not have been deemed necessary, especially in view of the fact that construction and maintenance of the river components would have been in addition to construction and maintenance of the road system. The Piercebridge formula, then, is illogical.

This is supported by the negative evidence for the Piercebridge formula in the North-east: no evidence was found for the adoption of Piercebridge formula components at ten sites in the North-east of England.

An alternative method of supply combines sea, road, and river transport. Most supplies with production sites long distances away would have been shipped by sea to a port in or near the North-east. These materials then would have been carted or transported by pack animals over the Roman road system to each fort. By the mid-Antonine period, ox-carts could have reached each fort in the North-east from a holding depot or from South Shields itself within two days, while pack animals could have made the same journeys within one day. In addition, many items could have been supplied locally, and transported either over Roman roads, native trackways, or rivers to each of the forts. However, rivers would have been used only when naturally navigable, and therefore, probably only in short stretches during certain times of the year.

As a closing note, it is likely that sea routes, roads, and naturally navigable rivers were used not only for transport of materials to and within the North-east, but were the main transportation media across Britain and the Empire, in lieu of the Piercebridge formula. Indeed, the problems of flooding and siltation endemic to river systems across Britain, which led to the virtual cessation in the 18th century of large-scale transportation along improved rivers, would have been even worse in the Roman period. Lower river and sea levels, together with a high degree of cultivation in the catchments especially of Lowland Britain would have greatly exacerbated flooding and siltation. In addition, Romano-British roads were much superior to those used in the Age of River Improvement. Therefore, it is unlikely that river improvement would have been considered, at least on the scale and by the methods suggested in The Piercebridge Formula.

As for the Empire beyond Britain, the great increase in cultivation charging the rivers of the Mediterranean basin with sediment during the Classical period, together with the absence of an effective lifting device, would have rendered a system of dams and locks as unviable across the Empire as upon the rivers of the North-east. In addition, although frequent mention is made throughout ancient literature of overland transport, particularly in the Edict and Codex, evidence is completely lacking in the ancient sources for river development according to the Piercebridge formula on the large rivers of the Empire. Therefore, the Piercebridge formula is not only untenable, but is unlikely to have been put into practice anywhere in the Roman Empire. Rather, rivers were used

as transportation media only when they were naturally navigable. Indeed:

> "Being inordinately fond of wine, [the Gauls] gulp down what the merchants bring them quite undiluted. They have a furious passion for drinking and get altogether beyond themselves, becoming so drunk that they fall asleep or lose their wits. Many Italian merchants, prompted by their usual cupidity, consequently regard the Gauls' taste for wine as a godsend. They take the wine to them by ship up the navigable rivers or by chariot travelling overland and it fetches incredible prices: for one amphora of wine they receive one slave, thus exchanging the drink for the cupbearer."
>
> Diodorus Siculus Works 5.26.3

Appendix A

MILITARY STRENGTH IN THE 3RD CENTURY NORTH-EAST

Estimating military manpower in the North-east during the Roman period is rendered very difficult by the fact that not all of the forts were in use throughout the whole period, and because the troop strengths at the occupied forts tended to vary (Davies, 1967). However, a very rough estimate can be gained by focussing upon known troop concentrations at certain forts within a specific period. The early 3rd century has been chosen because this period saw the greatest number of soldiers in the North-east after the Conquest (Breeze, 1984). The period ranges sometime after the withdrawal of Severus from Scotland at the beginning of the 3rd century, and before the gradual decrease in later 3rd century garrisons had begun. These garrisons seem to have been manned by nine different units, the values of which are by no means definitive. The identity and numerical value of each garrison is derived from Breeze and Dobson (1976, 140), E B Birley (1961), N Hodgson (1984, 49) Breeze (1984), and Daniels and Harbottle (1980), and is based on the assumption that certain units from the Hadrianic period continued throughout the 2nd century and into the early 3rd century, epigraphic evidence recording residence of certain garrisons in forts after Severus' withdrawal from Scotland, diplomas, and the Notitia Dignitatum.

Area 1:
Piercebridge: ? ala quingenaria
ca 500 foot, 500 equites
Binchester: ala Hispanorum Vettonum;
ca 500 foot, 500 equites
Chester-le-Street: ? ala quingenaria
ca 500 foot, 500 equites
Ebchester: cohors IIII Breucorum quingenaria peditata;
ca 480 infantrymen
Lanchester: cohors I Lingonum milliaria equitata;
ca 800 infantry, 240 equites;
Vexillatio Sueborum Longoviciensium Gordiana

Area 2:
South Shields: cohors V Gallorum quingenaria equitata;
ca 360 infantry, 120 equites.
Wallsend: cohors IV Lingonum quingenaria equitata;
ca 360 infantry, 120 equites.
Newcastle: cohors I Cugernorum quingenaria peditata; ca 480 infantry
Benwell: ala I Asturum; ca 500 infantry, 500 equites.
Rudchester: cohors (Frisiavonum?) quingenaria peditata; ca 480 infantry
Halton Chesters: ala I Pannoniorum Sabiniana; 500 infantry, 500 equites.
Chesters: ala II Asturum; ca 500 infantry, 500 equites.
Carrawburgh: cohors I Batavorum quingenaria equitata;
ca 360 infantry, 120 equites.
Housesteads: cohors I Tungrorum milliaria peditata; ca 1000 infantry
cuneus Frisiorum; unknown number of soldiers
numerus Hnaudifridi; unknown number of soldiers
Chesterholm: cohors IV Gallorum quingenaria equitata;
ca 360 infantry, 120 equites.

Great Chesters: cohors II Asturum quingenaria equitata;
ca 360 infantry, 120 equites.
vexillatio Raetorum gaesatorum; unknown number
Carvoran: cohors II Dalmatarum quingenaria equitata;
ca 360 infantry, 120 equites.
Corbridge: cohors quingenaria equitata;
360 infantry in two camps, so 720 infantry, 500 equites.

Area 3:
Risingham: cohors I Vangionum milliaria equitata;
ca 800 infantry, 240 equites.
numerus exploratorum; unknown number of men
vexillatio Raetorum gaesatorum; unknown number of
soldiers
High Rochester: cohors I Vardullorum milliaria equitata;
ca 800 infantry, 240 equites.
numerus exploratorum; unknown number of infantry
Blakehope: unmanned in 3rd century.
Chew Green: unmanned in 3rd century.
Low Learchild: unmanned in 3rd century.

In total, as many as 15,660 soldiers of the known units in the early 3rd century may have been stationed in the three areas of the North-east. Although the number of troops in the other units is unknown, it is generally held that they comprised less troops than the known units. However, it is likely that the combined number of these troops would have raised the total number in the North-east to about 17,000.

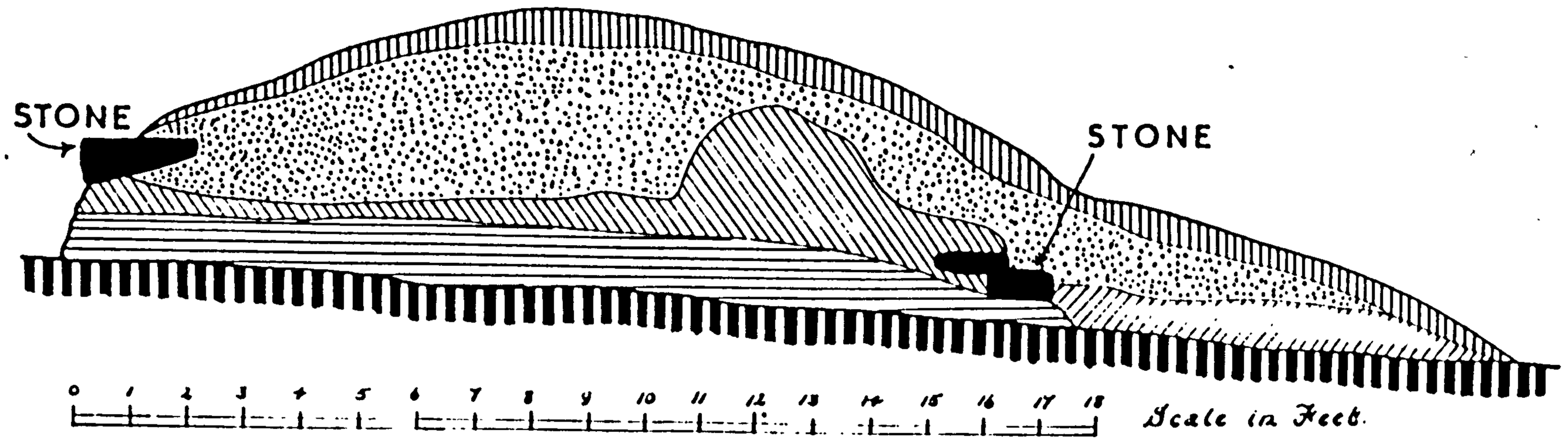


PLATE XVII

N.A.S.

Fig 85: Section through dam at Lanchester, from Steer, 1938.

Appendix B

A ROMAN PERIOD DAM IN THE NORTH-EAST

An idea of the character of a Roman dam in the North-east may be gained by an examination of the dam at Lanchester (figure 85). Steer's section (1938) of this dam reveals that the masonry used was about .5m wide. When multiplied by 4.7m high, over 60m length,[1] and multiplied by two for both the inner and outer walls, 282m cu of stone would have been required. In order to seal the clay within from flood damage, it is assumed that a layer of stone would have covered the top of the dam. Subtracting 1m from the combined width of the inner and outer masonry from the total width renders a covering 4.4m wide. Again, Steer's section suggests the masonry was .5m high. Multiplied by 60m, the covering would have been 132m sq, totalling 414m cu of masonry. As for the clay within, the height of 4.2m (minus the masonry surface above), multiplied by 4.4m width within the masonry walls, as well as the 60m length equals 1,109m cu of clay required.

---

[1] As discussed in the text (2.1.1), this length equals that of the bridge at Chesters.

B-1 STONE

Bidwell and Holbrook (1989, 48-49) have estimated the time required for quarrying, transporting, and laying the stone for Roman bridges on the northern frontier. Using their calculations (from Baker, 1909, 297), the amount of time taken to quarry a cubic metre of stone is 3.37 man/days. Thus 3.37 multiplied by 414 equals 1,395 man/days required to quarry the Lanchester dam masonry.

It is difficult to estimate the distance from which the stone used for the dam was transported, as no specifically Roman period quarry is known in the area. However, assuming that a quarry would have been sought as close as possible,[1] the figures used by Bidwell and Holbrook (1989, 48) for calculating the transport of stone to Chesters bridge will be used here. It is estimated that transporting 3,246m cu of stone necessary for Chesters bridge over 2km, at 1100kg per cart (discussed in text, 2.2.2), would have required 1270 man/days. As 414m cu stone required for the Lanchester dam is ca 1/8 the amount of stone needed for the Chesters bridge, transporting stone to the Lanchester dam would have required 159 man/days.

Baker (1909) argues that laying 1m cu of stone in a structure with the blocks hoisted by hand to a height of 6.1m would have taken 1.793

---

[1] As discussed in the text (6.2.3), the average distance between quarries and forts along the Wall is 1.6km.

man/days, totalling 742 man/days. Together, cutting (not including facing), transporting and laying the stone for this feature would have required 2,296 man/days.

B-2 CLAY

Jewell (1963, 58) and Startin (1982, 153) suggest that 1m cu of earth can be dug in one man/day, so that 1,109 man/days would have been required to dig this clay.[1]

The figures for transporting the stone above will be used here, so that 1,109m cu of clay would have required 423 man/days to transport to the site.

Again following the above figures for the laying of stone,[2] 1,940 man/days would have been needed to lay the clay between the masonry walls of the structure. Digging, transporting and laying the clay would have required 3472 man/days.

---

[1] That clay would have weighed about the same as other types of earth is logical if the clay was quarried in a dry state. However, in order to use the clay in the dam structure, dry clay would have to be hydrated at the site. If in fact wet clay was quarried, it would have been much heavier and stickier, and therefore more difficult to excavate than other types of earth, so that the above figures represent the minimum time required to excavate clay.

[2] However, if the clay required hydration at the site, laying the clay may have taken longer than that estimated for stone. Therefore, this figure represents a minimum time requirement.

In total, 5768 man/days would have been required to build this structure. Given that military rest days and festivals, as well as winter flood conditions would have allowed only 200 working days per year (Bidwell and Holbrook, 1989, 49), this equates to about 30 man/years. Therefore, a team of 30 men would have taken about one year to construct a river dam in the North-east. When projected across 199 dams necessary in the North-east, this equates to 1,147,832 man/days, 5,739 man/years, or 199 teams of 30 men working for one year.

	B.C. A.D.	500	1000	1500	1967
Tripolitania	E Roman dams and walls E	Roman sherds	Arab sherds	C^{14} 610	E
Cyrenaica	Greek and Roman sherds			photo glass	E
Tunisia	E Roman dams E	Roman sherds			E
Algeria	E Roman dams E	Roman and Punic sherds			E
Morocco	Punic, Berber and Roman sherds	Arab sherds	C^{14} 800	C^{14} 490	E
Spain	Roman sherds	Medieval sherds			E
Italy	Roman bath	Roman sherds	C^{14} 1400	C^{14} 1140 1534	E
Greece	Byzantine ruins	coins 565,575		Turkish midden	E
Jordan	Roman remains				E

E signifies erosion dominant in stream channels. C^{14}: radiocarbon dates for the alluvium cited in the relevant chapter. The shading indicates the maximum possible duration of stream aggradation as inferred from the relationship of the younger fill to archaeological remains.

Table 3: The Younger Fill. Vita-Finzi, 1969, 101.

Appendix C

ALLUVIATION IN THE ANCIENT WORLD

C-1 MEDITERRANEAN

Generally speaking, during the Classical, or 'Younger Fill' period,[1] much sedimentation occurred[2] across the Mediterranean basin. Recent evidence suggests that soil erosion and consequent increases in colluviation and alluviation across the Mediterranean between the period ca BC 500 - AD 500 resulted primarily from an expansion of population and agriculture (see Greene, 1986, 98-99). For example, historically documented flooding in Rome relates directly to forest clearance above the city (Giardina, 1981). This flooding ceased with a recession in agriculture in Central Italy, only to resume with increased cultivation in the Late Medieval period.

The steady growth of the Tiber river delta had necessitated an increase in the level of streets and houses at Ostia twice within two centuries, and by the 4th century, sedimentation had rendered the port virtually unusable (Ward-Perkins, 1962, 397).

---

[1] Vita Finzi (1969, 95-102) defines two periods of large-scale river valley sedimentation as 'Older' and 'Younger Fill', of which the latter includes the Roman period. Alluvium has been dated closely in some areas as it overlies buildings and dams in Roman period contexts (ibid.; see Table 3).

[2] Alluvia was recognizable by its predominantly buff and grey colour and its silty-fine sand composition (Vita-Finzi, 1969).

Similarly, constructed to facilitate navigation at the mouth of the Rhône, the Fossa Maxima was allowed to silt-up and pass out of use during the 1st century AD (Liversidge, 1968, 401).

Bronze Age population increase and its consequent intensification of agriculture were found to be critical factors governing the denudation of fertile soil across large areas of sloping land and its deposition in valleys on the island of Melos (Renfrew and Wagstaff, 1982, 94).

As discussed in Appendix G-5 and 6, alluviation over the Euphrates and Tigris permitted navigation over only certain stretches: along the Euphrates, a section representing only 1/10 the river's total length was wholly navigable.

C-2 ROMAN BRITAIN

Bell's researches (1981) across England show that sedimentation occurred at different times and places because of local agricultural activity, and that land-use factors were major influences upon sedimentation patterns in the Late Iron Age - Romano-British period. At the base of the Flandrian[1] sequence, fairly coarse gravels and sands are often buried by reasonably organically-rich, slowly-accumulated deposits with a black or grey colour (ibid., 86). Above these are often mineral-rich oxidized silts containing much less organic matter. Bell

---

[1] BC 8000 - BC 2000.

(ibid.) argues that the second layer coincides with the Late Iron Age - Romano-British periods, reflecting an increase in alluvial deposition across Roman Britain. On the Thames near Farmoor, Oxfordshire, alluvial deposition sealing Iron Age floodplain horizons seems to have been accumulated substantially by the 4th century (Lambrick and Robinson, 1979, 118). Potter has found evidence at Braughing in Herefordshire (1976) and Watercrook in Cumbria (1979) of late or post-Roman period alluviation or flooding. At Chester (mentioned in text, 6.3.1), structures presumably representing river supply in the Roman period, such as a quay wall and timber wharf west of the fortress, have been excavated from a considerable amount of silt. It seems that the continual process of silting, which by the end of the Medieval period seems to have destroyed Chester's earlier importance as a port, gradually pushed the channel westward (Thompson, 1965, 47).

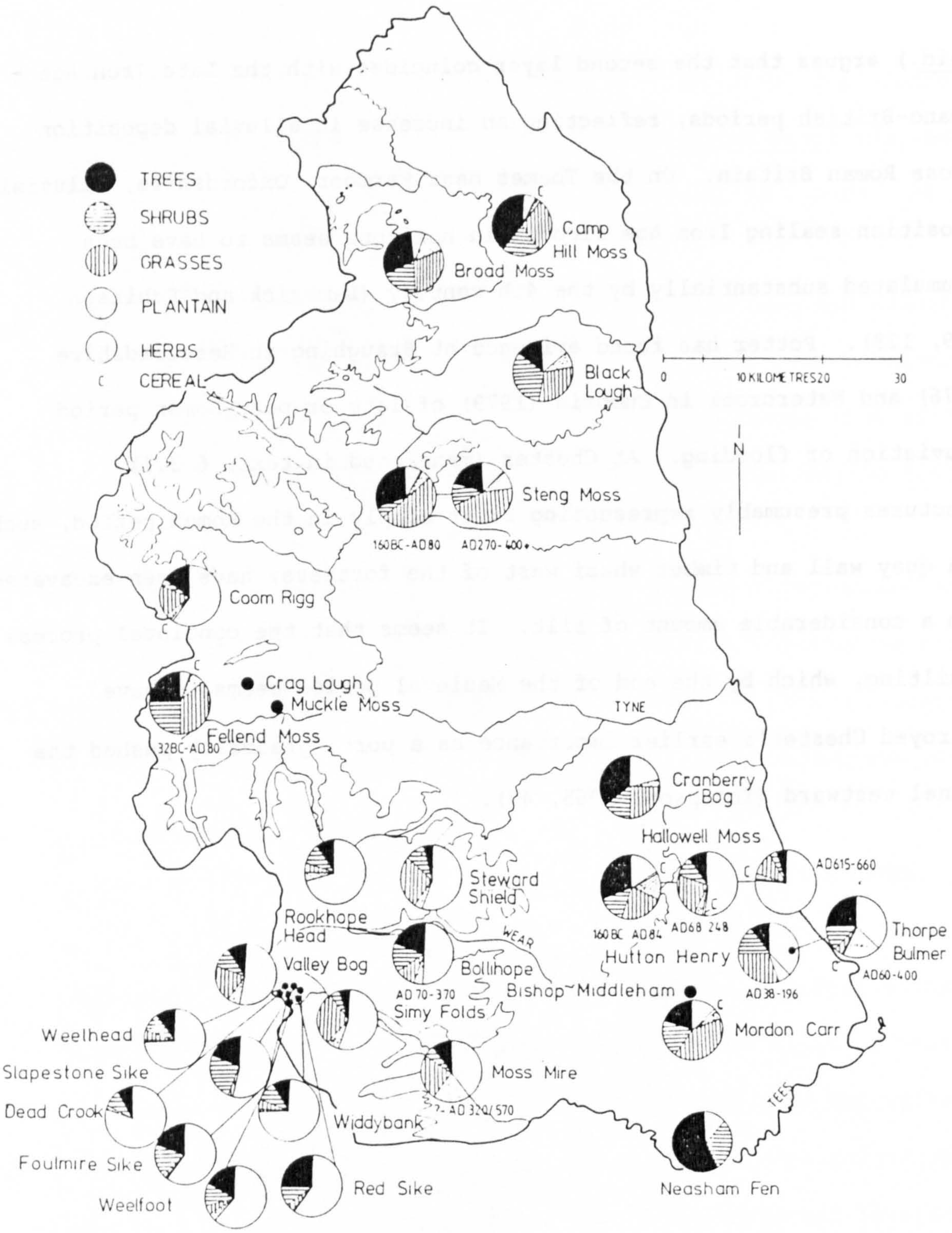


Fig 86: The environment of the Roman NE as shown by pollen diagrams, from Clack, in Miles ii, 1982, 389.

Appendix D

CULTIVATION IN THE NORTH-EAST

D-1 AREA 1

Up to 1984 (Haselgrove, 1984, 10), over 50 separate instances of crop-marks suggesting nearby Roman period settlements were found in the Tyne-Tees area. As for settlements, Thorpe Thewles (Heslop, 1983) grew from a large ditched enclosure begun shortly before the 1st century BC, expanding over the old boundary. Together with open settlements attested at Catcote (equipped with grain storage pits: Long, 1984) and Barwick, these settlements have yielded much evidence of native cereal production (Haselgrove, 1984, 12-13) during the Roman period.

Of seven pollen diagrams taken in an area[1] (Turner, 1979) corresponding to Area 1, six have indicated that much clearance took place during the period BC 100 - AD 200 (discussed in text, 2.1.2), that grassland and crops replaced these forests, and that the cleared land remained in use throughout the Roman period (ibid.; see figure 86).

Any evidence of cereal production in the diagram is significant. Because pollen samples are less likely to be contaminated in areas of

---

[1] Thorpe Bulmer, Hutton Henry, Neasham Fen, Valley Bog Moorhouse, Bollihope Bog, Hallowell Moss, and Steward Shield Meadow.

less cultivation, most of the samples were taken from Highland rather than Lowland regions. However, Highland soils of all three areas of the North-east are very acidic (Topping, 1989b, 145) and cereal pollen tends to perish. In addition, Plantago lanceolata, used as a pastoral indicator[1] is misleading, as it is found in arable fields as much as in pasture (ibid., 29). This is also the case for Rumex spp, and Ranunculaceae, which occur as arable weeds (ibid., 30). In addition, cereals (with the exception of rye) are self-pollinated, and unlike wind-pollinated species, are dispersed much less across the countryside (ibid., 30). Further, most of the diagrams were produced from buried soils, where an over-representation of a species is likely to occur, rather than bogs or lake deposits, which represent a general catchment (ibid.). Therefore, the sample of grain pollen recovered in pollen surveys to date represents only a minimum estimation of agricultural exploitation.

Further, if farmers were cultivating the marginal areas of the Highlands, it seems reasonable to assume that the more fertile Lowlands, cultivated throughout the millennia, were also being exploited (Jobey, 1966, 1). One might venture further that the use of Highlands for agriculture was in fact necessitated by the extensive agriculture taking place in the Lowlands.

---

[1] Turner, 1964; Godwin, 1968; Roberts, Turner and Ward, 1973.

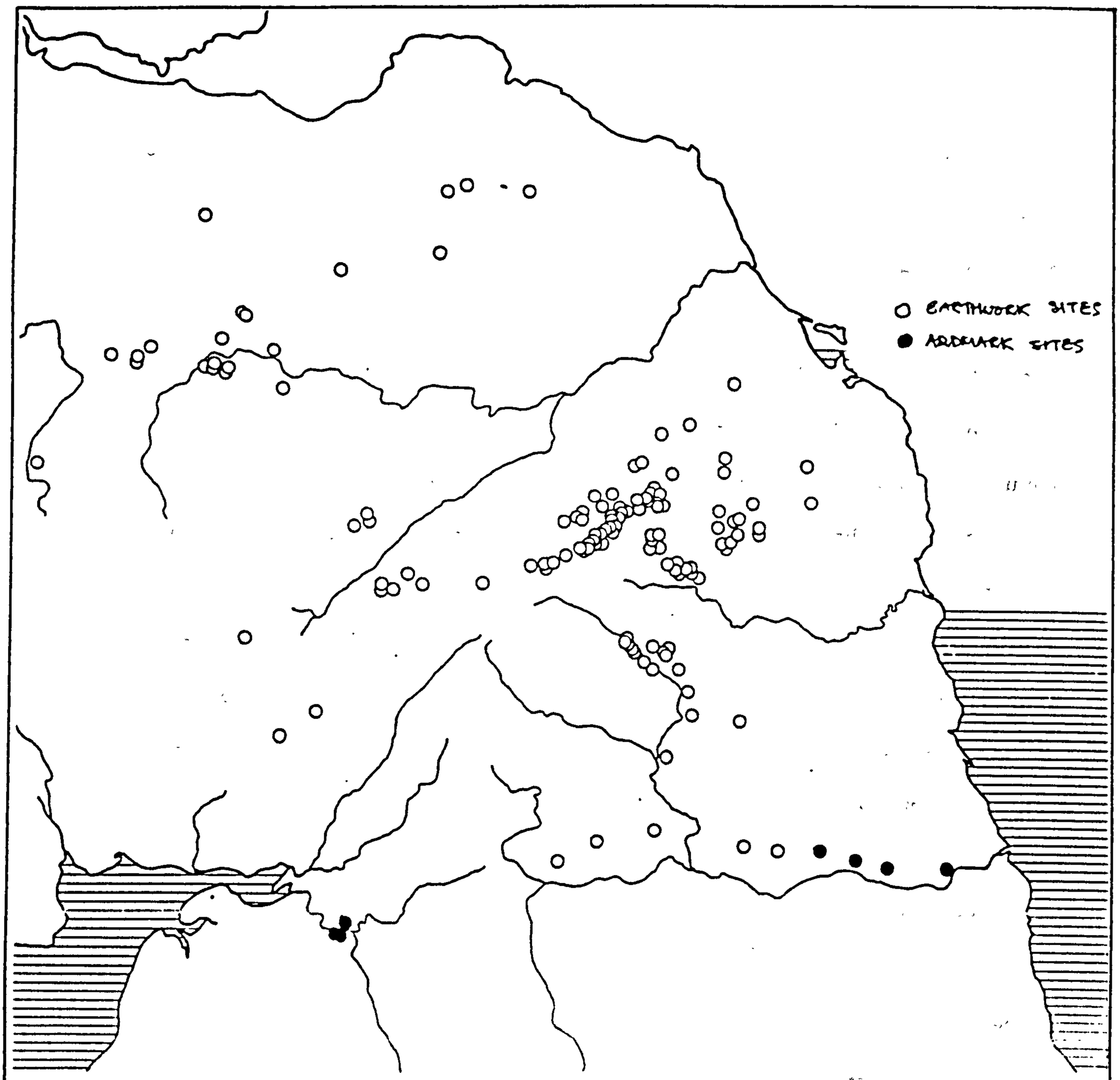


Fig 87: Cord-rig sites in the North-east: Areas 2 and 3, from Topping, 1989a.

D-2 AREA 2

Rather than Wall forts constructed in an 'agricultural vacuum' (Bennett, 1983), archaeological evidence attests to intense cultivation along the Wall line during the periods both preceding and during the Roman period.

D-2.1 Pre-Roman period cultivation

Sandstone chippings from construction work found in the bottom of "lazy-bed" plough marks on clay subsoil beneath Wallsend fort (NZ301660; Daniels in Goodburn, 1976, 308) suggest that the fort was constructed over a field recently ploughed. Further, the settlement from which these fields were cultivated may be represented by a complex of postholes north of the Wall (Goodburn, 1976, 308).

Cord-rig (Topping, 1989a)[1] was sealed beneath the Antonine fort at Newcastle (NZ250640), while at Rudchester fort, the absence of a turf line between the ploughed level and the lowest construction level led the excavators (Gillam et al, 1973) to suggest that the ground had been under cultivation immediately prior to its construction. Topping (1989a) argues that ridges, forming multi-axial alignments, sometimes oblique or

---

[1] This cultivation consists of parallel ridges generally no more than 1.4m between the centre of the furrows, made with a plough, an ard, or perhaps with a spade (Topping, 1989a). Working fields in this way may have been for climatic reasons: ridges can increase soil temperatures substantially, and therefore yield potential (ibid., 5).

at right angles to the original lay-out, suggest a long and intense period of arable activity.

Ard marks were found beneath Hadrianic Halton Chesters (NY997685) and the headquarters building at Carrawburgh (NY859712), and multi-axial alignments similar to those at Rudchester appear at Greenlee Lough (1.5km north-west of Housesteads fort - NY775696), abandoned sometime before construction of a Roman camp.

In addition, cord-rig has been found in association with many Wall structures other than forts. Although some of these marks may have been created in preparation for construction, such as at a Westgate Road milecastle, Newcastle upon Tyne (Harbottle, Fraser, and Burton, 1988, 155),[1] other evidence suggests pre-Roman period cultivation.

Evidence for ploughing was found under the Military Way at Walker (Jobey, 1965), and at Denton Burn (NS 201655) ploughmarks on various orientations as well as final ploughing furrows (Brit, 1989, 433) sealed by construction deposits of Hadrian's Wall are considered cord-rig (Topping, 1989a). Plough marks also have been recorded in the vicinity of the milecastle, and beneath and north of the vallum's north mound at Wallhouses (NZ044684) (Bennett, 1983). At Tarraby Lane (NY405575),

---

[1] Palaeo-botanical analyses of soil from the buried ground surface attests to the lack of ploughsoil in this area, and that the milecastle was constructed in an uncultivated area of wood and grassland (Harbottle, Fraser, and Burton, 1988, 155).

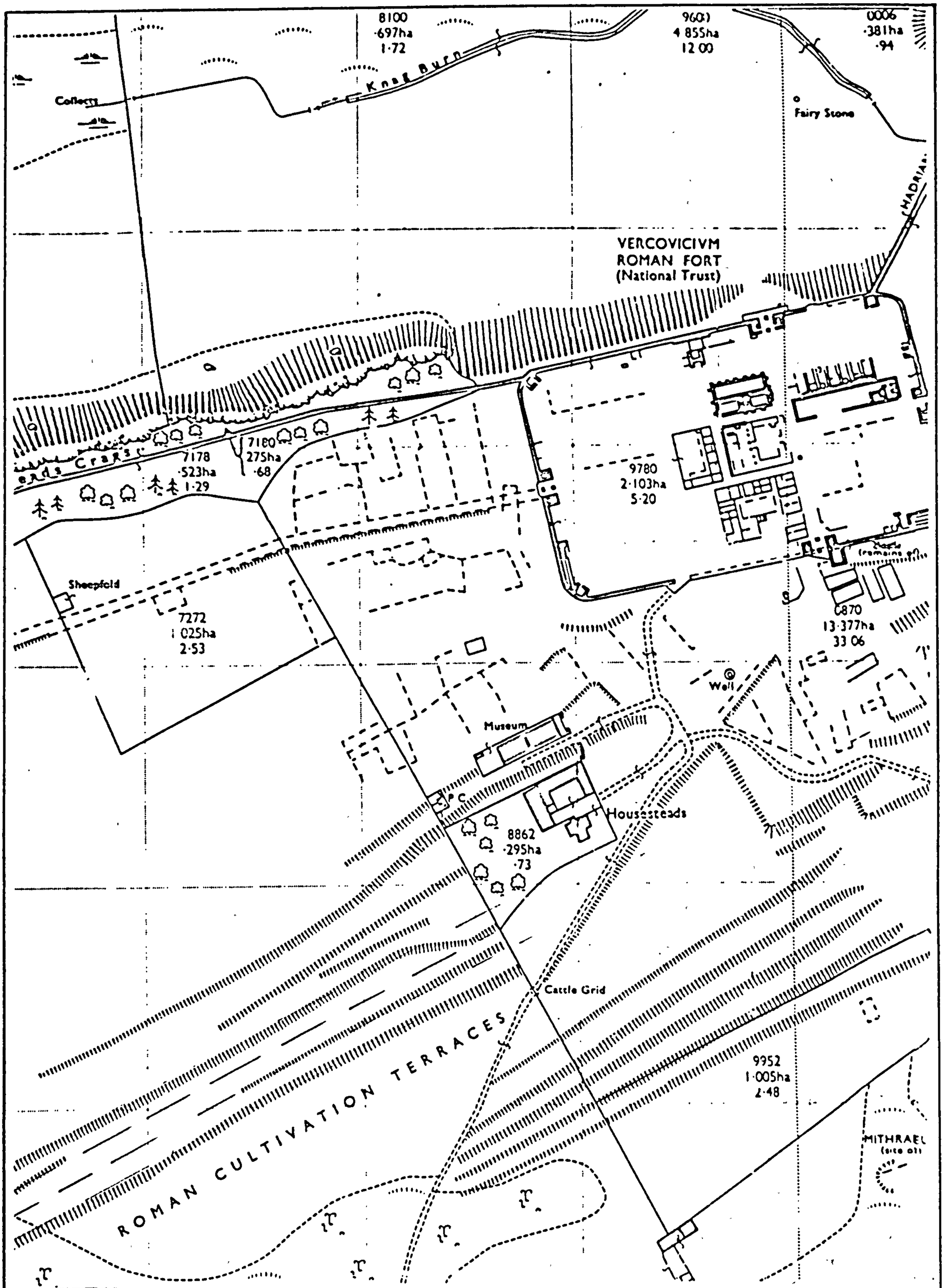


Fig 88: Housesteads cultivation terraces, from RCHME, Newcastle, 1990.

uniaxial ardmarks in rectilinear field systems are overlain by Hadrian's Wall, and dated to ca BC 130 (Smith, G H, 1977, 374). Finally, plough marks have been found beneath a Roman camp at Haltwhistle Burn (NY716662) (Topping, 1989a).

In all, cord-rig (usually ard marks) has been discovered in what are mostly pre-Hadrianic levels beneath more than a dozen forts and associated military structures along Hadrian's Wall from Wallsend to Carlisle (Gates, 1981, 35).

D-2.2 Roman period cultivation

A Romano-British field system probably existed at Housesteads (see figure 88). Five successive phases of cultivation in the area have been identified, the earlier of which may have been pre-Roman or Roman period in date (Fowler, 1983). Woof (1986, 88) argues that revetted terraces overlain by a Medieval field-system at nearby Sewingshields, from which Roman period pottery has been recovered (below), suggests a Late Romano-British date for their use, and may indicate a similar date for the terraces at Housesteads. Such suggestions have since been borne out by excavation. J Crow (1989, 37) examined a terrace running between the museum and farm at Housesteads by excavating two trenches, 140m from the fort's west gate. Four successive features were noted below the terrace wall: a palisade of stake, a gully cut by a pit (later than AD 180), and two phases of timber fence. Whinstones comprised an extant revetting wall .6m wide and .25m high, a structure which might be related to the

3rd century vicus (ibid.) On the basis of this, Crow has concluded that the terraces running across the hill slope below the fort and beyond to the west probably date to the Roman period and possibly were returned to cultivation in the 16th century, while the opposing strips and banks running downhill are of the post-Roman period.

At Corbridge, the scatter of 2nd century pottery from the Agricolan supply base at Red House suggests that land was given over to cultivation after destruction of the base. Furthermore, the presence of 4th century pottery on the same site suggests that agricultural activity continued throughout the Roman period (Hanson et al, 1979, 35).

Pollen recovered at Vindolanda outside both fort and vicus, as well as from a ditch fill (dated to AD 100-125), indicates that the environment of this site was largely treeless in the Roman period. In addition, the indication of cereals and a variety of pastoral and arable weeds suggests that crop rotation was being carried out in the vicinity of the fort in the early 2nd century (Turner, 1979, 288).

At Fell End Moss, west of Vindolanda and overlooking Hadrian's Wall, pollen diagrams have dated forest clearance to AD 20-60, and a corresponding increase in crops and pasture plants (Davies and Turner, 1979).

The most important source of evidence for cultivation of Roman period fields near forts along the Wall is cord-rig. Fields beneath Wall

structures had been cultivated using cord-rig not only over a long period previous to the Roman period, but were cultivated right up until the Hadrianic Wall structures were constructed over them. Therefore, as cord-rig cultivation is known from the Iron Age, and as the original forts were constructed in the North-east in the mid-70's, fields in the North-east must have been cultivated using cord-rig at least fifty years into the Roman period.

In addition, excavations have revealed other features which may represent agricultural activity. Róman period pottery has been recovered from the revetted terraces south of the milecastle at Sewing-Shields (Haigh and Savage, 1984). Hanson (1977, 13) has suggested that features previously thought to be a Romano-British settlement at Croy Hill may represent allotments for farming. Finally, ditches and gullies located east of the fort at Moresby may indicate cultivation in the Roman period (Bennett, 1981, 328).

D-3 AREA 3

Recent ground investigation near enclosed stone-built settlements and aerial photography have revealed certain facts concerning Romano-British field systems. Together with pollen diagrams, this work indicates a marked increase in the level of arable farming taking place in this area prior to and during the Roman period.

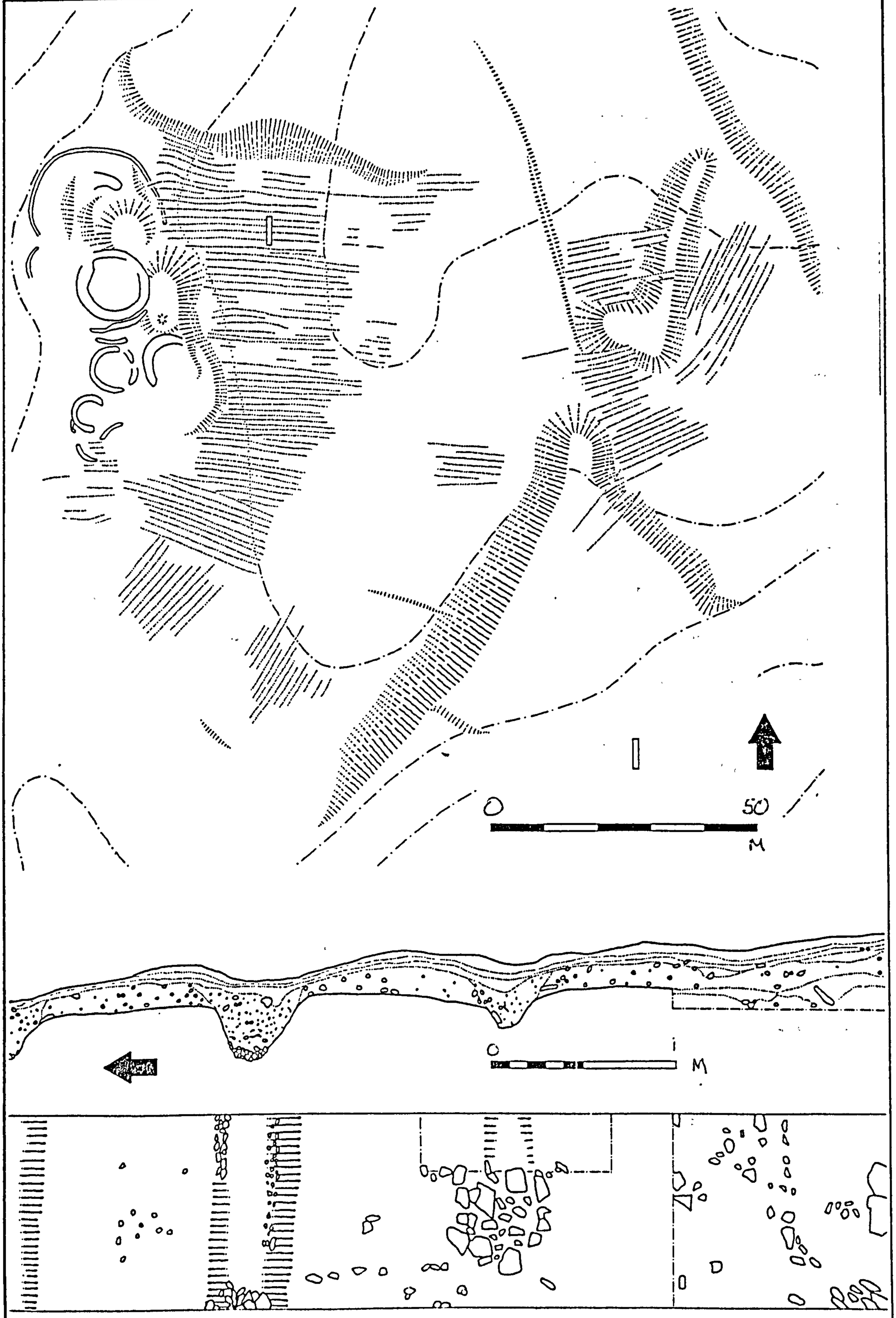


Fig 89: Cord-rig Fields on Hut Knowe North, Nthbld., from Topping, 1989a.

D-3.1 Pre-Roman period cultivation

The over 150 cord-rig fields found in Area 3 and the Borders are associated with a wide range of settlement types (Topping, 1989a) in the pre-Roman period.

> "...in the case of cord-rig, we are dealing with a form of agriculture which was fairly universal in application."
>
> Topping, 1989a

Again, the association of cord-rig with Wall structures in Area 2 suggests that cord-rig was carried out from the Late Iron Age into the Roman period.

D-3.2 Roman period cultivation

It seems that the average size of field systems increased in the Late Iron Age, Romano-British periods. First, the surveyed fields[1] are .5 - 1.75 ha compared to .2 ha fields probably worked in the early 1st or 2nd millennia (Gates, 1981, 33). In addition, numerous Roman period rectangular buildings, plough rigs, and dykes suggest such a proliferation of field systems (ibid., 21).

Second, many rotary querns found in Romano-British contexts throughout the North-east indicate that cereals were being consumed to a greater extent in this period than before (Wilson, 1983, 112), and perhaps that

---

[1] Estimates can be made only of those with a continuous perimeter.

cereal production had increased.

Third, evidence suggests an increase in stone houses reflecting settlement expansion (Gates, 1981, 38). The amount of stone houses increased on almost one third of the extant Romano-British settlements in the North-east, Berwickshire, and Roxburghshire, where house remains are still preserved (Jobey, 1974). Gates (1981, 38) has calculated that four groups of Romano-British fields out of five are associated with settlements with definite signs of expansion as shown by an increase in the number of stone houses.

Fourth, evidence suggests that land used for pasture in the pre-Roman period was turned over to agriculture. As mentioned in the text (6.2.3), Gates (1981, 32) argues that trackways linked 'stockyards' within the Romano-British settlements to unenclosed ground: these trackways, therefore, can be interpreted as drove roads leading to pastures beyond the fields. This would imply further that it was necessary to exclude animals from the fields at least for certain periods during the year. If so, the fields were presumably in arable cultivation or used for growing hay in the spring and summer, though they also would have been available for cultivation at other times of the year or during the fallow periods (ibid.).

Given the extent of cultivation attested by the number of pre-Roman period cord-rig systems, and given the evidence of increased arable farming on Romano-British settlements, extensive agricultural

exploitation was carried out in the Late Iron Age and Roman period in Area 3.

D-4 CONCLUSION

Altogether, the evidence suggests the North-east was under extensive cultivation in the Roman period. It may be argued further that these Roman period levels of cultivation are unparallelled. Indeed, pollen diagrams from Area 1 suggest that farmers were cultivating the marginal Highland areas, and in Area 3, many cord-rig field systems have been identified because they lie at altitudes far higher than cultivated fields of subsequent periods. Cord-rig is found often at ca 420m OD, while the next highest field systems are 13th-14th century broad rig, and Napoleonic field systems at ca 210-300m OD (pers comm Pete Topping). As discussed, the relationship of cord-rig immediately below many Wall structures suggests that this cultivation belongs to the Late Iron Age, and may have continued well into the Roman period. Again, if farmers were cultivating these Highland areas in the Roman period, it seems reasonable to assume that the more fertile Lowlands, cultivated throughout the millennia, were also being exploited. Therefore, it is likely that Roman period agriculture was more extensive in the North-east than in any period since (pers comm Pete Topping).

KARATAS

DROBETA

PONTES

KAZAN GORGE

DANUBE

EGETA

ROMAN CANAL

OVER 200m

ROMAN FORT

TABULA TRAIANA

1:25,000

0

10KM

Fig 90: Iron Gates.

Appendix E

A ROMAN PERIOD POUND-LOCK?

"It is often quoted by archaeologists that the Romans had no knowledge of lifting devices such as pound-locks, but I hope to convince readers otherwise."

Selkirk, 1983, 84

It is thus argued in The Piercebridge Formula that pound-locks were used in the Roman period, the technology was forgotten, and 're-invented' in the 14th century. The argument is based on the assumption that because there was a great necessity for pound-locks, the technology must have been developed. Pound-locks would have been used either in canals which had already been constructed, or which were still in the planning stages.

E-1 EVIDENCE SUPPORTING A ROMAN PERIOD POUND-LOCK

A 4km by-pass canal around the Iron Gates along the lower courses of the Danube would "definitely need lifting devices to accommodate a change of levels" (Selkirk, 1983, 83). Although evidence for pound-locks has not been found, "no doubt traces will come to light" (ibid.; see figure 90).

Pliny the Younger as governor of Bithynia proposed to Trajan in 112 (Tra., 10.41-62) a canal which would have needed pound-locks (Selkirk, 1983; Moore, 1954). The canal would link Lake Sophon (now Sabanja, 30km south-east of Nicomedia) 40 cubits (36m) above sea level to a navigable

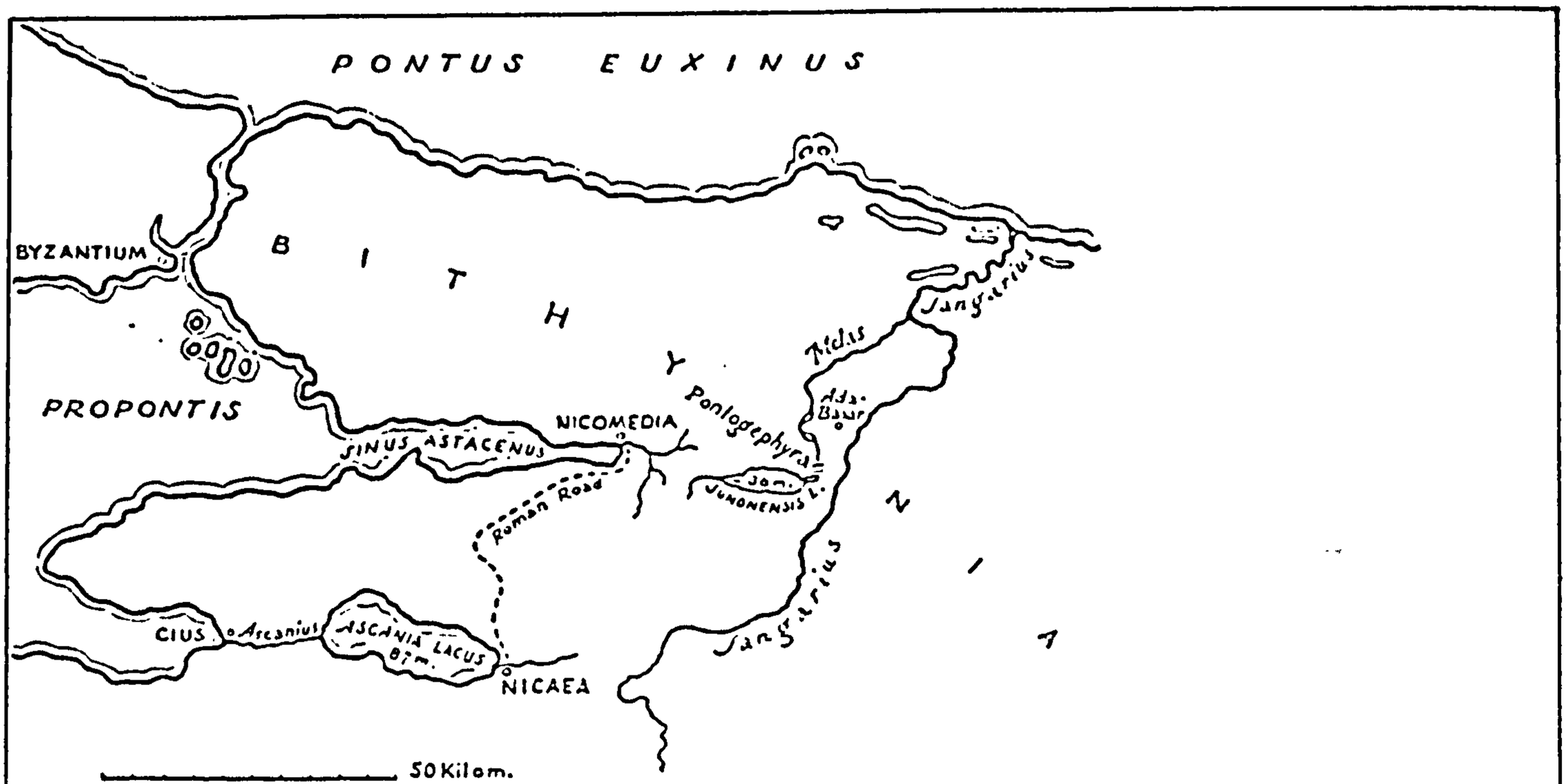
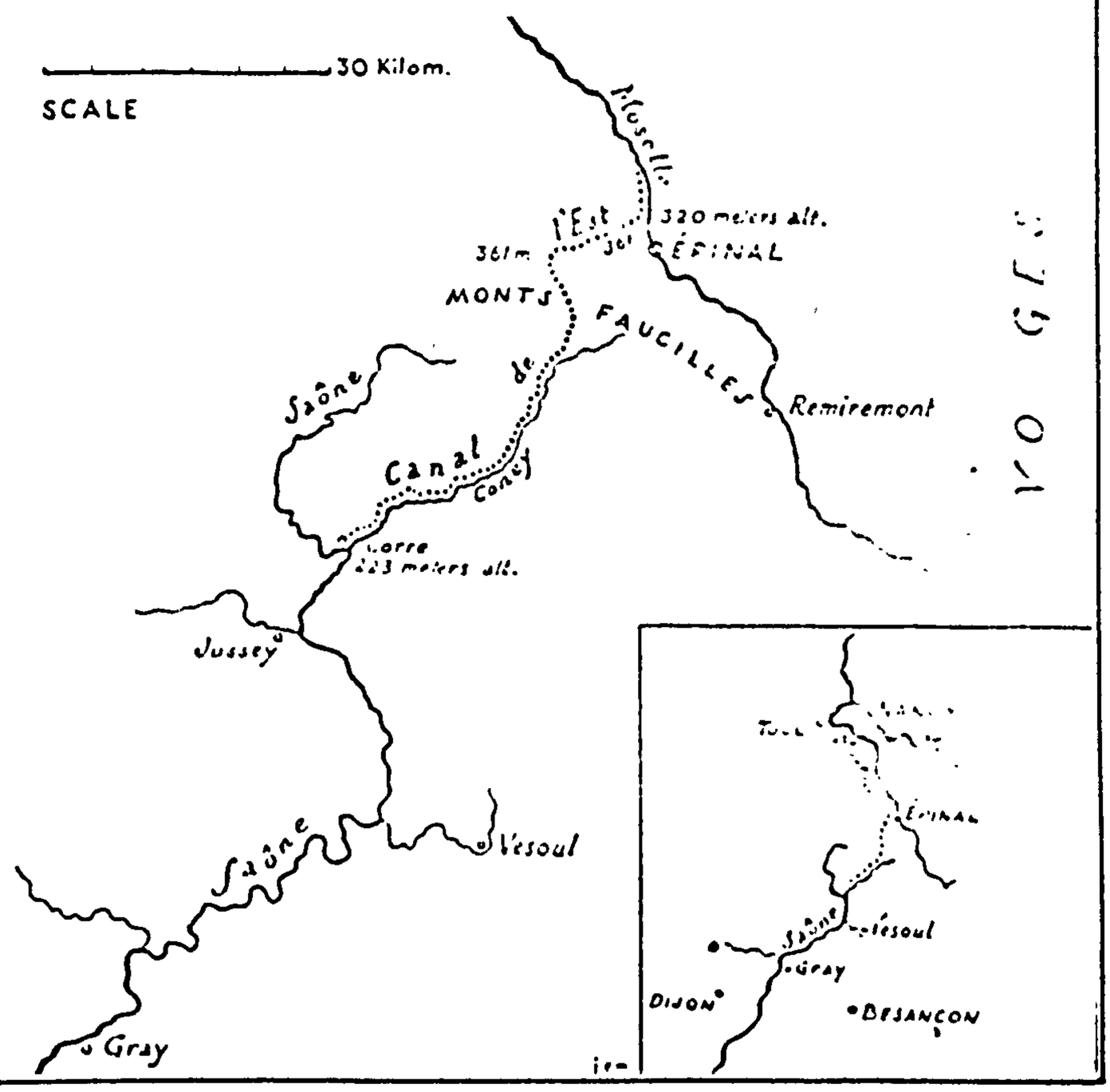


Fig 91: The region of the proposed Bithynian Canal. From Moore, 1954.

Fig 92: The region of the proposed Saone-Moselle Canal. From Moore, 1954.



river emptying into the Propontis Sea (see figure 91). A waterway to the sea would facilitate exploitation and stimulate trade of goods around the lake[1] far more than the present system of overland cart transportation (10.41). Trajan replied (ibid. 10.42) that an engineer should be consulted lest the lake be "completely drained once ... given an outlet to the sea" (ibid. 10.42). In reply, Pliny suggested (ibid. 10.61) a number of proposals to counter this eventuality. Among other things, he suggested damming the natural river and regulating water flow by cataractae (ibid., 10.61.4-5). As Trajan leaves the matters in Pliny's hands (ibid. 10.62), it must mean that they were "not worried about level changes in their artificial waterways", and that cataractae must have been pound-locks (Selkirk, 1983, 88). Moore argues (1954, 99) that this project is "inconceivable" without pound-locks to facilitate navigation from sea to lake, and that it is particularly significant that after Pliny's first letter Trajan was not deterred by the 40 cubits.

Evidence for a pound-lock is also found in Tacitus' mention of a proposed Saône-Moselle canal:

> "Vetus [Lucius Antistius] prepared to connect the Moselle and the Arar [Saône] by running a canal between the two [AD 58]; so that goods shipped by sea and then up the Rhône and Arar could make their way by the canal, and subsequently by the Moselle, into the Rhine, and in due course into the ocean: a method which would remove the natural difficulties of the route and create a navigable highway between the shores of the west and north."
>
> Tacitus Ann 13.53

---

[1] Pliny claimed that this area was very wealthy in marble, farm produce, wood and timber.

Connecting these rivers would have required construction of a canal over a natural watershed (see figure 92), perhaps near the modern Canal de L'est (Allen, 1933, 67). This canal, beginning at the junction of the rivers Saône and Coney, rises from 223-360m OD,[1] and requires 60 pound-locks (Moore, 1954, 108).

Indeed, the mere contemplation of this scheme reflects a knowledge of pound-locks: if the watershed had been deemed insurmountable, army engineers - architecti and libratores - or their superior officers - praefecti castrorum - would have informed the generals before the plan was proposed to Nero (Moore, 1954, 103). Ultimately, Vetus and Paulinus - another general planning the construction - could have abandoned the plan at any time before the proposal. It can be concluded from the degree of commitment to this project that it must have been deemed tenable (Smith, N A F, 1978, 82; Selkirk, 1983, 94).

A pound-lock also may have been used in a canal between the Nile and Red Sea. Intermittently throughout antiquity, boats crossed from the Red Sea to Mediterranean by means of a canal between the Red Sea and Nile, probably about 9.6km long (Smith, N A F, 1978, 82).[2]

---

[1] In one section, the canal rises ca 39m in 3.2km.
[2] After construction apparently by the Pharoah Sesostris I (BC 1971-1929, 12th Dynasty; Diodorus Siculus Works 1.33.11), the canal fell into disuse, was rebuilt later and used consecutively by Necho ca BC 600, Darius in BC521, and Ptolemy Philadelphus at the beginning of the 3rd

After Trajanic restoration in AD 98, the canal continued in use until the 3rd century AD (Smith, N A F, 1978, 82). Strabo states (Geog. 17.1.25) that the Ptolemies, when cutting their canal, "made it so that it could be closed". Moore argues (1954, 99) that nothing is said about haste, so that barges could navigate in and out of the canal without hindrance. Unlike the Suez canal of today, the canal would have been subject to the seasonal variations in the water level of the Nile, and maintaining static levels would have been compounded by the Red Sea tides (today about 2m; Moore, 1954, 99): in short, a passage from one body of water to another only would have been possible with the employment of a pound-lock.

Moore (1954, 99) cites Pliny the Elder (HN 3.53) describing efforts for rendering the river Tiber more navigable by means of piscinae. These apparently accumulated a share of water which was released by a sluice gate. Piscinae must have been provided at either end with two cataractae, which could have been raised or lowered by windlasses (Moore, 1954, 99).

A parallel may be drawn between the use of pound-locks and dry-docks (Smith, N A F, 1978, 83), which were used in the ancient period for boat-building and repair.[1] As the pound-lock essentially works on the

---

[2] (cont'd)century BC.

[1] Athenaeus of Naucritus (ca BC 200) describes invention of dry-docks by a Phonecian (in Sarton, 1959, 120-1), and Cicero (De Oratore, 1.62) writes that Hermodorus of Salamis, living in Rome in the 2nd century BC, designed and built navilla, or dry-docks.

same principle as the dry-dock, the knowledge gained from the use of dry-docks may have been applied to canal engineering. Men such as Marcus Agrippa, an admiral, general, and engineer responsible for ports and canals, may have combined knowledge of ship-building with canal navigation (Smith, N A F, 1978, 83).

E-2 EVIDENCE REFUTING A ROMAN PERIOD POUND-LOCK

E-2.1 Iron Gates

The exact course of the canal mentioned above is unknown, but is thought to lie between Tekija and Karatas near the modern canal of Sip. Indeed, an inscription recording construction of Trajan's canal was found only 3km from this modern canal. In addition, this part of the Kazan gorge is the most difficult passage to navigate (Petrovic, 1968), and the most likely place to skirt with a canal.[1]

Although much gravel and other material of the Roman canal was excavated during construction of the modern Sip canal, an earthen wall of Trajan's canal has nevertheless been traced from the castle at Karatas,

---

[1] The inscribed marble slab found 150m south-east of the fortress of Karatas attesting to construction of the canal in 101 reads: "... ob periculum cataractarum derivato flumine tutam Danuvi navigationem fecit." The cataractae are rocks in the water, rapids, straits and whirlpools common in the Danube between Golubac and Karatas, especially at the Iron Gates (Petrovic, 1968, 84). The bed of the Danube is wide at this point, but its course is traversed by a number of natural cataracts. At low water, navigation is impossible, and when full, the passage has many hidden dangers (ibid.).

extending in a straight line towards the stream Kasanjna, almost parallel with the modern Sip canal, and appearing intermittently near its terminus (Petrovic, 1968). Unfortunately, the terminus, probably near the mouth of the river Kosovica, was completely destroyed by the building of Sip village. Two massive walls found in the bed of this river are thought to have regulated the uncertain current of the river during construction of the bridge (ibid.). Nothing described within the extant remains is suggestive of Roman period pound-locks.

Even before the modern Sip canal was constructed, the Roman canal was described in 1892 (Petrovic, 1968) as curving slightly southwards 150m from the rocky Danube bank within two artificially-banked earth walls 14m high, 10m wide at the base, and 3.2km in length. No pound-lock structures were described.

This is not wholly surprising, as the character of the canal militates against pound-lock construction. A by-pass canal with pound-locks in a static system would have required a water depth just deep enough for the passage of barges. However, at 14m high, the walls of this canal seem to have been designed to receive the full force of a diverted Danube flow. Therefore, it does not seem that this canal was constructed merely to facilitate a change of levels: it was more in order to avoid the cataracts of the Iron Gates.

This suggestion is supported by Procopius of Caesarea (Buildings, 4.6.16) describing a canal constructed downriver from the Iron Gates

canal. After Apollodorus had constructed for Trajan a bridge to span the Danube between Pontes and Drobeta, it was destroyed by "floods and the passage of time", so that:

> "... when boats reached that point, the river was no longer navigable, since the ruins and the foundations of the bridge lay in the way; and it is for this reason that they compel the river to change its course and to go about in a detour, so that they may keep it navigable beyond that point."

This canal, and likewise possibly the Iron Gates canal, was constructed in order to avoid obstructions rather than to change levels.

In addition, the Tabula Traiana found in the Kazan Gorge in the 16th century attests to a road built in AD 100 along the banks of the Iron Gates further upriver from the canal (see Petrovic, 1968). Begun in the AD 30's, the final section of this road was completed under Trajan, in the year before construction of the canal had commenced. If pound-locks were known in the Roman period, this road suggests strongly that they were not used at the Iron Gates.

Indeed, it appears that the road was built to facilitate navigation of a river with a strong current. The inscription describes widening and deepening of the cliff road through the rock face, and modern accounts (Petrovic, 1968, 88) attest to its cutting through 3km of perpendicular rocks along the Danube. The inscription also suggests that the road was equipped with a wooden structure which jutted out over the river (Mócsy, 1974, 109) to facilitate barge towage. That barge haulage was carried out from this road is attested by rope grooves cut into the rocks of Gornja and Donja Klisura (Petrovic, 1968, 86).

The enormous effort of constructing a road and boardwalk, as well as the presence of rope friction marks are inconsistent with a pound-lock 'closed' system, wherein a static river would have allowed easy navigation of barges punted or paddled. On the other hand, the friction marks suggest that barges were pulled against the strong current of an 'open' system unrestricted by static barriers. It seems that the Danube below this road was not developed in the Roman period, and that Roman period bargemen pulled barges through the many rapids and whirlpools still present in this part of the river today (Petrovic, 1968, 84).

E-2.2 Bithynia

Trajan and Pliny the Younger seem ignorant of the potential advantages gained by employing the pound-lock in Bithynia. Trajan's worry over the draining of Lake Sophon once it was linked to the sea is crucial (Coupland, 1987, 85). Indeed, after stating that the lake "might be completely drained once it is given an outlet to the sea" (Tra. 10.62), Pliny considers in his final letter on the matter "the danger of [the lake's] water draining away" (ibid. 10.62). If the pound-lock and its advantages in water conservation had been known, neither Pliny nor Trajan should have been so concerned.

Pliny the Younger's suggestions (Tra. 10.63) to avoid the draining of the lake are also conspicuous. A dyke could be left to "keep [the canal and river] apart" over which goods could be trans-shipped, and/or a river flowing from one end of the lake could be dammed. Lake water used in the

canal could be limited by using water from a number of streams flowing into the canal's course. However, the concern over lake water drainage reflected in these solutions would have been unnecessary if a pound-lock system could have been employed. Rather, these alternatives suggest that the canal's cataractae served a semi-closed flash-lock system designed to regulate large amounts of flowing water, rather than the static water of a closed pound-lock system.

Finally, Pliny suggests that if the canal was cut longer and deeper, it could be brought directly to the sea, rather than to the river and to the sea, and the counter-pressure of the sea would check the outflow of the lake. Again, if pound-locks were employed, such counter-pressure would have been irrelevant.

That Trajan and his army engineers were unaware of pound-lock technology is further illustrated by his contemplating the re-opening of a canal built under the earliest Assyrian Kings, known as the King's River (Cassius Dio, Roman History 48). This canal, connecting the Euphrates and Tigris, would have facilitated transport of boats between the two great rivers. However, Trajan decided against it because the water of the Euphrates, at a much higher level than the Tigris, "might rush down in a flood and render the Euphrates unnavigable" (ibid.).[1] Again, as Trajan could not conceive of a method to keep the Euphrates

---

[1] Trajan instead used hauling-engines to drag the boats across the space separating the two rivers.

river from flooding the Tigris once connected, it does not appear that he or his engineers knew about the virtues of pound-lock water conservation.

E-2.3 Saône-Moselle Canal

Tacitus' account (Ann. 13.53) of this proposed canal must be taken in context: indeed, he may have exaggerated the commitment Vetus had for the project.

> "The scheme was nullified by the jealousy of Aelius Gracilis, the governor of Belgica, who discouraged Vetus from introducing his legions into a province outside his competence and so courting popularity in Gaul, "a proceeding," he said, "which would awaken the misgivings of the emperor [Nero]" -the usual veto upon honourable enterprise."
>
> Tacitus Ann 13.53

Tacitus may have described this episode to illuminate the jealous tendencies of a Roman governor, and second, to pontificate against suppressing another's initiative for self-serving purposes.

However, if the proposed canal had actually been viable, but was suppressed in the end by a jealous governor, it is conspicuous that the scheme was not later revived (Charlesworth, 1926, 189). Indeed, this enterprise would have greatly facilitated transportation from the Mediterranean to the Rhine and North Sea, and apart from the practical applications, the prestige value of constructing such a system would have been considerable. Indeed, if tenable, the system would have been considered under later emperors such as Trajan and Hadrian, conspicuous for their engineering projects. The fact that no further mention of this

canal was made suggests that its construction was outside the competence of army engineers.

Rather, it is likely that this proposal was on the level of 'whim'. Indeed, the period was one of quiet prevailing in Germany, and because of the low potential for gaining kudos from a military victory, the army generals, Paulinus and Vetus, may have sought glory from a public work such as this. When the logistical realities of constructing a viable system over this watershed (without pound-lock technology) hit home, the project was abandoned.

E-2.4 Nile-Red Sea Canal

Sherwin-White (1966, 648) disagrees with Moore's interpretation of Strabo's 'device' on the Red Sea-Nile canal, contending that neither Strabo nor Diodorus make reference to a pound-lock or double cataractae. Rather, the difference in water levels (3 cubits, or 1.4m) could have been overcome by the use of a single gate and an awareness of the Red Sea tides. N A F Smith (1978, 82) also argues that some sort of stanch or flash-lock would fit equally as well both the description and situation.

E-2.5 Further Evidence

As for linguistic evidence, Sherwin-White (1966, 647) refutes Moore, stating that the Latin word piscinae meant 'fish weirs' with gates - emissi, while Coupland (1987, 81) argues that cataractae and piscinae may have been flash-locks. Latin authors use no terms which can be translated definitely as 'weir', 'sluice', 'flash-lock', 'pound-lock', and cataractae mean no more than 'walls', 'barriers', or 'water-falls' (Smith, N A F, 1978, 85). As mentioned, along the Iron Gates of the Danube, cataractae refer to 'rapids' which were avoided by cutting a by-pass canal.

Although an application by Agrippa of dry-dock technology to canal construction seems logical, a pound-lock may not have seemed necessary in the Roman period. During many phases of the Roman period there existed vast pools of labour and resources, so that the rewards of time and energy-saving devices may not have been appreciated as they have been since the Industrial Revolution. Indeed, although in the Roman period many colours were used to dye clothes, parchment and papyrus were used for writing, and dies for minting coins, and even though high literacy rates in some areas and at certain phases may have made a printing press valuable, the three were not combined to anticipate Guthenburg. On the other hand, perhaps the consummate factotum Agrippa was aware of the detrimental effects (discussed in text, 2.1.2) which closed systems have upon rivers' regimes.

E-3 CONCLUSION

In total, not one of the arguments supporting a Roman period pound-lock stands-up to scrutiny, and on present evidence, nothing suggests that pound-lock technology was known in the Roman period.

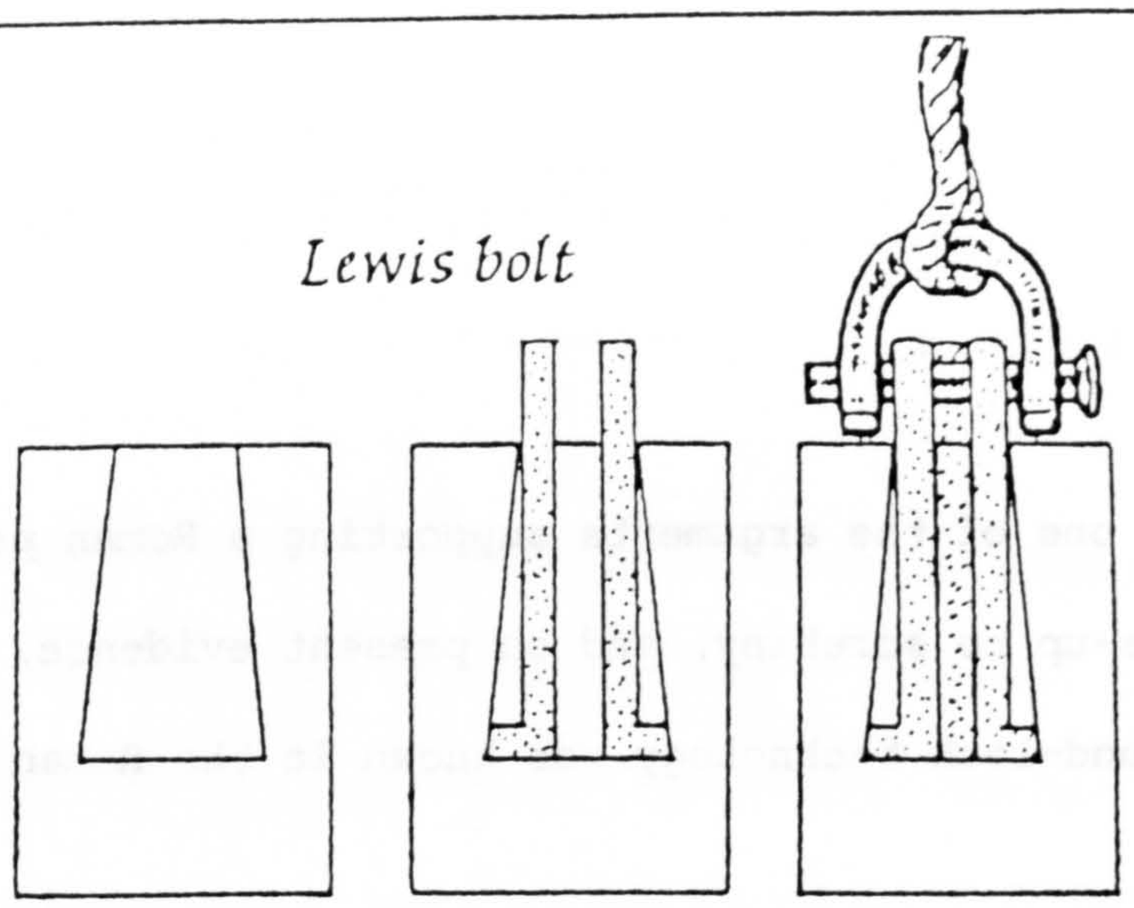
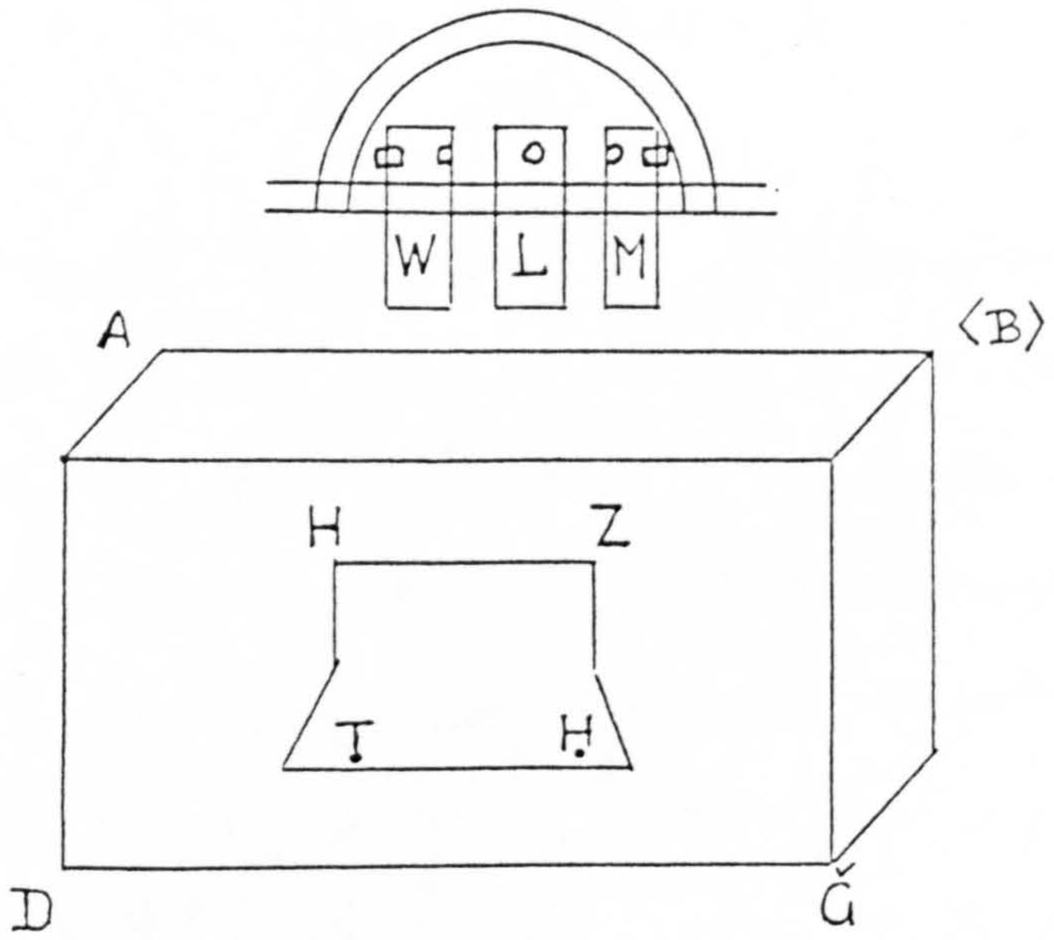
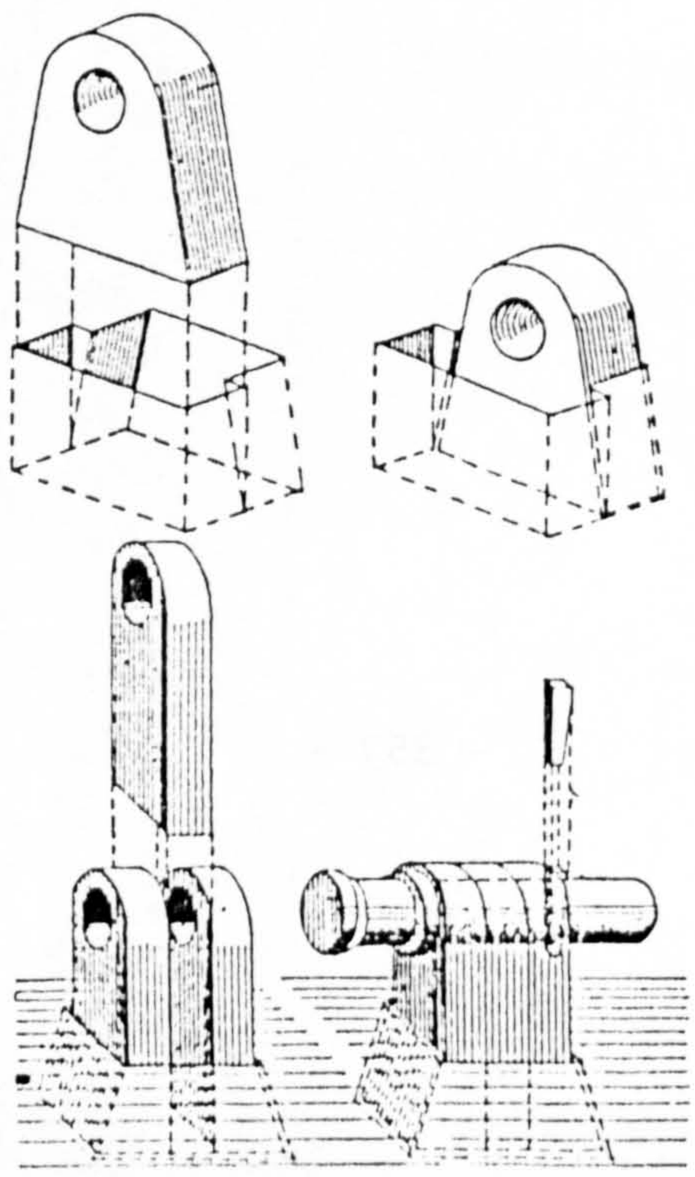


Fig 93: The Lewis-hole, from Hero 3.6-8

Fig 94: The Lewis-hole, from Landels, 1978.





Appendix F

THE LEWIS-HOLE AS DATING EVIDENCE IN THE NORTH-EAST

The lewis-hole is a rectangular-shaped cavity cut into a block of masonry. From the surface, the hole is cut increasingly wider, its sides sloping out at an angle of 4-5 degrees so that the base is wider than its aperture. It is designed to hold a 'lewis', consisting of three pieces of iron arranged so as to form a dove-tail. The outside pieces, described by Hero (Automata 3.8) as having a 'gamma shape', are wedged into the hole with the insertion of the third piece between the two. The three pieces are then connected together by a pin passed through them (see figure 93, 94). Once inserted and secured into the lewis-hole, the stone can be lifted. The advantage of a lewis is that it can be used to lower a block onto a flat bed without having to move or support it from below. The derivation of the name 'lewis' is not known, although it might recall the builder who re-introduced it after the Roman period (Partridge, 1958, 367).

The existence of a lewis-hole in masonry is often cited as dating evidence in The Piercebridge Formula (Selkirk, 1983). Because the technique was known in the Roman period, and because no literary reference has been attested for the lewis-hole before the 18th century, it is reasoned that any stone containing a lewis-hole dating before the 18th century must belong to the Roman period.

F-1 EVIDENCE SUPPORTING THE PIERCEBRIDGE FORMULA

The known literary evidence supports this argument. In Northumberland, Bede (Complete Works, 1843-44) records that Benedict Biscop sent for masons from Gaul to build Jarrow Church in 674, suggesting that there were no trained masons in Northumberland during the latter half of the 7th century (Wilson, D M, 1976, 260), and that Roman period masonry skills had died out by this time.

Instead of the lewis-hole, Medieval illustrations depict a variety of baskets, barrels, and other receptacles used for lifting stone (Salzman, 1952, 322). Large blocks were lifted usually by means of 'slings' - stout ropes hitched round the stone and over a hook at the end of the lifting rope. At Westminster in 1348, a rope, weighing 6.4kg, was bought 'for the slyngges' (ibid.), and 'slynging ropes' occur at Cambridge in 1508 (ibid.). A horse-hide for making 'le slengg' is mentioned in 1323 in Ely (ibid.). In addition to the sling, a reversed 'grip' was used: two crescent-shaped irons hung from a common ring, with their convexities facing inwards and their lower ends inserted in holes drilled olbliquely in the stone. These 'pincers' were used at Windsor in 1357, and at Langley in 1368 (ibid.)

It seems that the lewis-hole is not referred to in literature before 1740, when Pineda mentions a device in a Spanish dictionary: "by us called a Luis hole" (Murray, 1933, 233). After this, the word is used in 1742 in Britain when Defoe writes: "the lewis-holes are still left in

many of the stones" (ibid.). Again in the same year, Stukeley writes: "At each extremity a stone of Arthur's Oon to be suspended by the lewis in the hole of them" (ibid.). The last reference in the 18th century is Smeaton, who wrote in 1793: "The instrument we now call the lewis, is of an old date" (ibid., 232). The lewis-hole cannot be traced through literature before the 18th century, nor is it possible to ascertain what Smeaton considered "an old date".

F-2 OTHER ARGUMENTS

Some evidence exists for the use of the lewis-hole between the Roman period and 18th century Britain. Salzman (1952, 322) has found a rough sketch of a lewis used as a mason's mark on one of the Norman pillars in Gloucester cathedral, which suggests very strongly that the lewis-hole was known and used in Britain from the end of the 15th century.

F-3 CONCLUSION

On the basis of Salzman's evidence (albeit slight), only when lewis-holes appear in structures dating between the 5th and 15th centuries can the date of the stone be assumed from the Roman period. Therefore, the date used in The Piercebridge Formula as the latest possible date for the re-introduction of the lewis-hole into Britain is three centuries too late.

Appendix G

LITERARY EVIDENCE FOR THE PIERCEBRIDGE FORMULA ACROSS THE EMPIRE

G-1 TIBER

The River Tiber, rising near Arretium in the Appenines and winding into Narnia, running south-west through Rome and into the Tyrrhenian Sea at Ostia over a course 400km long, is central Italy's greatest river, and was a vital supply link to the city of Rome from the 1st century BC onwards. Grain ships from Sicily, Sardinia, North Africa and Egypt, as well as Gaul, the Chersonese, Spain and Cyprus (Pliny the Elder HN 18.66-8) would sail into Ostia and afterwards into Portus, and the cargo would be transferred into barges and hauled up the Tiber to Rome. The importance of this grain supply to Rome cannot be overstated. With a population peaking at perhaps 1,000,000, Rome would have required at least 150,000 tonnes of grain annually (Garnsey, 1983, 118). Therefore, the Tiber was arguably the last link of the most important supply route in the Roman Empire.

Pliny the Elder writes (HN 3.53) that although the Tiber was navigable to Rome from Ostia for boats of any size, the river was subject to frequent sudden floods, disrupting navigation. In addition, during the Gothic War:

> "... when the merchants reach the harbour with their ships, they unload their cargoes and place them in the barges, and sail by way of the Tiber to Rome; but they do not use sails or oars at

> all, for boats cannot be propelled in the stream by any wind since the river winds about exceedingly and does not follow a straight course, nor can oars be employed either, since the force of the current is always against them. Instead of using such means, they fasten rope from the barges to the necks of oxen and so draw them just like wagons up to Rome."
>
> Procopius of Caesarea The Gothic War 5.26.9-17

An exceedingly winding course and strong current suggests against the development of the Tiber with static barriers below Rome.

The Tiber above Rome also was very important to the city for the supply of foodstuffs, building stone and timber (Strabo Geog 5.2.10, 5.3.7-11; Pliny the Elder, HN 8.8.3). However, it appears that little effort was made to make this vital supply link more navigable. Indeed, the rugged and uneven channel of the Tiber above Rome rendered it unnavigable for a long distance to anything but rafts (Pliny the Elder, HN 8.8.3). Barges also supplied Rome with goods brought down the Tiber's tributaries. Building materials were supplied via the Anio, and other goods via the Nar and the Teneas through Ombrica, and the Clanis, through Tyrrhenia and the territory of Clusium (Strabo, Geog. 5.3.7). The system of sluices mentioned in the text (2.1.3) which sometimes necessitated a wait of nine days, was also applied to the Tiber's tributaries, such as the Tinia and the Chiana (Pliny the Elder, HN 3.53). The Anio was navigable only before Tibur, after which a waterfall (Strabo Geog. 5.3.11) fell down from a great height into a deep wooded ravine. At this point, the river flowed through a plain past the quarries of the Tiburtine, Gabii, rendering "delivery from the quarries and the transportation by water ... perfectly easy" (ibid.).

The lack of static barriers along the river was likely due to problems of siltation. The accumulation of sediment at the Tiber's mouth often choked harbour works, eventually forcing Claudius to excavate a separate artificial mouth. In addition, sediment washed down the Tiber was continually advancing the coast-line at Ostia.[1] Given the amount of sediment in the river, it is unlikely that static barriers would have been a viable aid to navigation.

Despite the importance of the river to the supply of the city of Rome from the granaries overseas or in the hinterland of Italy itself, it seems that the Tiber was not developed at any point along its length with Piercebridge formula components.

G-2 RIVERS OF GAUL

The large rivers of Gaul were for the most part naturally navigable.

> "The whole of the country is well-watered by rivers, some of which flow from the Alps, the others from the Cevennes and the Pyrenees. Of these some flow into the ocean, the others into the Mediterranean. For the most part they flow through plains or hilly country with navigable rivers. The courses of the rivers are so excellently disposed in relation to one another that goods can be conveyed from either sea to the other; for the cargoes must be conveyed over the plains for only a short distance and that without difficulty, while for most of the journey they travel by the rivers, in the one case going up into the interior, in the other going down to the sea. The Rhône is provided with special advantages in this regard; for it has tributaries joining

---

[1] As discussed in Appendix C-1, at the beginning of the 4th century, the growth of the Tiber delta had already rendered Ostia virtually unusable and forced its citizens to raise the level of streets and houses twice within two centuries (Ward-Perkins, 1962, 397).

> it from many directions, as I have said, and it flows into the Mediterranean which is more advantageous than the Atlantic, and passes through the most fertile land in this part of the world."
>
> Strabo Geog 177

Although the province was 'well-watered', it seems that when river development would have greatly facilitated river-borne transport, obstructions in the various rivers were merely avoided. Indeed, a little later in his description of Gaul when describing the four routes from the Mediterranean to the Atlantic, Strabo tells us that the first led from Narbo (Narbonne), following the course of the Atax (Aude), which soon became too shallow for navigation, and wagons had to be used before reaching the Garumna (Garonne), which could be navigated to Burdigala (Bordeaux). The second route, beginning along the Rhône valley, soon required a cart journey to the Loire (Strabo Geog. 189):

> "The current of the river Rhone was so strong that it was difficult for merchantmen from Italy to make their way upstream... as a result, some cargoes were carried by wagons to the territory of the Averni and the Loire."

The only mention in the ancient sources of river development which would have facilitated navigation along the inland waterways in Gaul was the proposed Saône-Rhône canal. As discussed in Appendix E-2.3, this canal was never constructed.

G-3 RHINE

The River Rhine became the Roman frontier in north-western Continental Europe with Caesar's campaigns, and so remained until the period between the Flavians and ca 260, when the frontier of Germania Superior lay further east. The military used this waterway as a medium of supply and communication for the forts situated along its length, and maintained a fleet - Classis Germanica - from BC 12, with its headquarters at Cologne. The importance of the Rhine as a supply route is underlined by Ammianus, who describes in the mid-4th century how British grain was regularly shipped to the mouth of the Rhine, and then transported by riverboat to the hinterland of Gaul. This traffic, he writes, was interrupted when barbarian inroads removed the lower Rhine from Roman control:

> "Some ships continued to ply, but since they discharged their cargo in coastal ports, the grain had to be conveyed by wagons instead of by river transport, and that was a very expensive undertaking."
>
> Ammianus Marcellinus 18.2,3

Despite being the main artery of supply and communication to the troops on the German limes, the Rhine, navigable from its headwaters, was not restricted with Piercebridge formula static barriers.

> "... and it could be navigated from its very source, since it overflows with waters of its own, did it not run along like a torrent rather than a quietly flowing river."
>
> Ammianus Marcellinus Works XV. 4.2

One static barrier existed, although it served military strategy rather than navigational purposes. During the revolt of Civilis, Cerialis pursued Civilis with three extra legions and auxiliary cavalry.

> "Civilis had built a dam obliquely into the Rhine, so that the river, thrown from its course by this obstacle, flooded the adjacent fields... the ground ... was treacherous for our men because the shallows were uncertain and therefore dangerous."
>
> Tacitus Hist 5.14

Drusus cut a canal and raised a dyke near the delta of the Vecht (one of the two outlets of the ancient Rhine river) in order to regulate the flow along the bottom stretches (Tacitus Ann 13.53). This project was completed by Pompeius Paulinus in AD 55, but destroyed by Civilis in AD 70 to hinder a Roman pursuit (Tacitus Hist 5.19). However, the dyke was constructed in the delta, below the tidal mark, and functioned to control the current of the Rhine, rather than to facilitate a change in levels for river craft. Tacitus notes the current of the Rhine in its bottom stretches (Hist 5.23; Ann 2.6), as does Pliny the Elder (HN 4.14.101,106). If static barriers had been in place above the dyke of Drusus and Paulinus, the current would have been of no consequence.

Some evidence suggests that the lack of river development sometimes impeded navigation. On stretches midway along the river, during an episode in the Germanic War:

> "the Rhine hardly floated boats, owing to a drought unprecedented in that climate; reprovisionment was hampered; detachments were posted all along the bank of the Rhine to keep the Germans from fording it, and for the same reason there was less grain while there were more to eat it."
>
> Tacitus Histories 4.26

Therefore, the Rhine was not developed at any period, at any point along its course with Piercebridge formula components.

G-4 DANUBE

With construction begun under the Flavians of a series of forts along its limes, the Danube became one of the most important supply routes in the Empire (Mócsy, 1974, 109). It was by this river that forts along the river in Lower and Upper Moesia, Pannonia, Noricum, Raetia and for a time Dacia were supplied by the Danubian fleet.

As discussed above (Appendix E-2.1), obstructions in the river Danube along the bottom section of the Kazan Gorge, the Iron Gates, were overcome in the Roman period by the construction of a canal attested by an inscription, and probably located in the area of the modern Sip canal (see figure 90). In addition, a canal was constructed to by-pass the obstacles produced by the wreckage of the bridge of Apollodorus built a short distance downstream from the Iron Gates. However, these measures

were taken to overcome the obstacles only because they posed insurmountable navigational problems. During construction of modern canals in the Derdjap, no other traces of ancient canals were found. It seems that in the Roman period, the worst part of the gorge was avoided, while the greater part - replete with cataracts, rapids, and whirlpools - remained undeveloped: barges were pulled through these areas against the current.

Impediments to river transportation also seem to have existed along the Upper Danube. Despite the close proximity of the river, in the Late Empire, two units under the dux of Raetia were converted into overland supply units. When a law was passed which granted exemptions from furnishing animals to the public post (Codex, 11.16.15.382), because of the gravity of their situation, such exemptions did not apply to these Raetian units (see Jones, A H M, 1973, 844).

It is also conspicuous that although Tacitus (Hist 3.46; Ann 2.63, 4.5, 12.30) Appian (Ill, 22.1,3,6), Cassius Dio (Roman History, 49), and especially Pliny the Elder (HN 3.22.2; 4.18.2; 9.17.2,20,5; 31.19.1) wrote prolifically about tributaries, islands, towns, inhabitants on both sides and the fishes of the Danube, no mention is made of Piercebridge formula components of dams or locks. Rather, the most difficult obstacles were avoided, and the course of the river remained undeveloped.

G-5 EUPHRATES

The Euphrates rises in the Armenian mountains, flows south-west to the Taurus, then south-east, receiving its three main tributaries - the Murat Su, the Balikh, and the Khabur - on the right bank. In the alluvial plain of Babylonia, the Euphrates was connected with the Tigris by numerous navigation and irrigation canals. By the Roman period, after the recognition of the Parthian Arsacid king as ruler of Armenia, the upper and middle course of the river became the limes. Forts along its right bank guarded for more than 500 years the imperial frontier against first the Parthian, and later the Sassanid kings.

That the lower Euphrates below Babylon was navigable in the Roman period is not disputed. Strabo (Geog. 16.1.13) states that the Euphrates was navigable to Babylon over a distance of 3,000 stadia, or 590km, while Ammianus Marcellinus (Works 23.6.11) lists nearby Teredon as its furthest navigable point. Pliny equivocates:

> "Nearchus and Onesicritus report that the Euphrates is navigable from the Persian Sea to Babylon, a distance of 659km; but subsequent writers say it is navigable up to Seleucia, 696km."
>
> Pliny the Elder HN 6.30

When describing Julian's campaign against the Saracens, Ammianus writes of troop reinforcements making their way up the river to meet him a short distance downstream from Callinicum:

> "... his fleet arrived, equal to that of the mighty king Xerxes, under the command of the tribune Constantianus and Count Lucillianus; and the broad Euphrates was almost too narrow for it, consisting as it did of a thousand cargo-carriers of varied

construction, and bringing an abundance of supplies, weapons, and also siege-engines; there were besides fifty warships and an equal number which were needed for making bridges."

Ammianus Marcellinus Works 23.3

However, the estimated navigable stretch of the river falls well short of its total length, which is estimated by Strabo to be 36,000 stadia (7020km) (Geog 16.1.13). If correct, the river was wholly navigable for only 1/10th of its entire length. Even along this stretch, Ammianus (Works, 23.3) states that "after many losses, the Euphrates mingles with the deep". The 'losses' have been described[1] as the dimunition of the depth and speed of the Euphrates due to the accumulation of alluvial deposits.

As for the area above Babylon, it was only navigable in certain areas. In Severus' journey down the Euphrates above Babylon, it seems that Severus:

"... constructed boats on the Euphrates and proceeded forward partly by sailing and partly by marching along the river... Thus he soon seized Seleucia and Babylon."

Cassius Dio Roman History 76

Pliny (HN 5.20) writes that the river was navigable over 80km from Dascusa to Sartona, and again after the Cataracts to Samosata, the capital of Commagene. Mitford (1980, 1176, note 9) argues that the Euphrates' current in the upper stretches confined navigation to

---

[1] See commentary for Ammianus Marcellinus, by Rolfe, 1963, 355.

downstream traffic, and Roman river-borne traffic could have been managed over the main rapids in the Antitaurus and Kurdish Taurus only with rafts made of inflated skins.

It seems that the river Euphrates was developed for agricultural rather than navigational purposes. According to Strabo (Geog. 16.1.9), dams were constructed in canals flanking the entire length of the river. The dams prevented flood waters from deluging the canals during the flood season, and helped contain water left over from the flood season to be used for agriculture. These dams were not equipped with sluice gates which would have allowed water to enter slowly from the canals.

> "...there is also need of quick work in order to close the canals quickly and to prevent all the water from emptying out of them. For when they dry up in the summer, they dry up the river too."
>
> Strabo Geog. 16.1.9

Strabo suggests that the water needed for the canals in the summer lowered the depth of the Euphrates itself, so that many voyages were thwarted by either too much or too little water in the river, as the water in the canals was often either excessive or lacking.

In total, it seems that only one section comprising 1/10 of the entire length of the Euphrates was wholly navigable. Even in this section navigation sometimes would have been difficult. Although the Euphrates was dammed, these static barriers were part of an irrigation system, and were not intended to facilitate barge passage. In the absence of any recorded lifting devices, these barriers would have impaired navigation.

G-6 TIGRIS

The second of the two great rivers of Mesopotamia, the Tigris flows from Armenia south-east through Assyria and Babylonia to the Persian Gulf. On its left bank it receives three main tributaries, the Greater and Lesser Zab and the Diyala, and discharges into the Persian Gulf through two mouths. Like the Euphrates, the Tigris was wholly navigable only over its bottom stretches, or from the Gulf to Seleucia (Strabo, Geog. 16.1.9), which was ca 200 stadia (24km) from Babylon on the Euphrates (16.1.21). Again, it seems that this river was exploited primarily for agriculture rather than navigation. The river flowing through the original home of the barcarii of South Shields, then, was not developed with Piercebridge formula components.

G-7 NILE

The organization of the shipment of grain down the Nile for mass export began in the Ptolemaic Period. After the annexation of Egypt to Rome in BC 31, grain collected along the Nile was barged downriver for export to Rome on a regular basis (Garnsey, et al, 1983, 72). The importance of Egypt's grain supply was owed not only to its fertile and irrigated soil, but because no part of the country lay far from the Nile, its flood-waters, or a navigable canal (Jones, A H M, 1973, 843-4), so that transport costs were relatively inexpensive.

Among the projects along the Nile, a harbour was constructed in the area of Alexandria. Tacitus (Ann 2.60) records as one of many sites witnessed on Germanicus' tour of Egypt "the excavated lake which receives the overflow of Nile" - the Lake Moeris of Herodotus, south of Memphis. Strabo also noted this inland harbour constructed under the Ptolemies:

> "...many canals from the Nile drain into Lake Mareotis both from the south and on each side of the lake and many more goods are brought in this way than from the sea, with the result that the Lake Harbour is richer than that on the Mediterranean."
>
> Strabo Geog 17.1.7

According to the sources, this project, which facilitated transfer of goods from the Nile barges into warehouses and sea-going ships, is devoid of Piercebridge formula components.

That there was a necessity for lifting devices along the Nile is shown in a passage from Pliny:

> "Elephantis is an inhabited island 6.4km below the last cataract and 25.6km above Aswan; it is the extreme limit of navigation in Egypt, being 936km from Alexandria... Elephantis is the point of rendezvous for Ethiopian vessels, which are made collapsible for the purpose of portage on reaching the cataracts."
>
> Pliny the Elder HN 5.10.58

Apart from a possible lock system on the Nile/Red Sea canal discussed in Appendix E-1, construction of a system of dams across this river, given the strength of its yearly flood[1] and the likelihood of

---

[1] Strabo records (Geog 17.1.3) that it could rise 14 cubits (6.58m).

destruction for anything barring its way, was probably deemed impossible (until the modern period). In addition, the importance to agriculture of the silt deposited with the receding floods[1] - the so-called 'Gift of the Nile' - may have discouraged everyone before Nasser from tampering with the Nile's regime.

Along the length of a river peopled by a civilization flourishing over some 2700 years before the Romans claimed Egypt as a province of the Empire, no evidence suggests its development with Piercebridge formula components.

G-8 CONCLUSION

Although describing major rivers in much detail, such as the best places to build bridges, the tribes inhabiting the areas along the rivers, and even the types of fishes found within, ancient authors do not describe Piercebridge formula components along major waterways of the Roman Empire. This con trasts to the frequent mention of overland transport throughout the Empire. As discussed in the text (2.2), the Edict of Diocletian and Codex of Theodosius refer specifically to costs and regulations governing overland transport. Indeed, transport costs appear in the first chapter of the Edict, while the chapter entitled Cursus Publicus is by far the longest and most detailed in the Codex.

---

[1] When the Nile registered only 8 cubits (3.76m), a famine would ensue (Strabo Geog 17.1.3).

Thus, if the Piercebridge formula operated across the Empire, given the quantity of components necessary to make the system viable, a great deal of attention should have been devoted to the subject in the ancient sources: the complete lack of mention must mean that Piercebridge formula components did not exist on the most important communication and supply arteries of the Roman Empire.

Indeed, even when navigation could have been facilitated or increased, it seems the rivers were not equipped with dams or locks. It is likely that the Tiber, Euphrates, Tigris, and possibly the Nile were so prone to alluviation that the imposition of static barriers would have aggravated greatly the already existent problem of siltation. As for the Danube, the most difficult stretch was avoided by a by-pass canal.

Appendix H

GRAIN SUPPLY IN THE NORTH-EAST DURING THE ROMAN PERIOD

H-1 AMOUNT OF GRAIN NECESSARY

H-1.1 Soldiers

It has been estimated that each soldier was rationed between .9kg and 1.36kg per day of grain, which was made into bread, porridge, pasta and soup. Polybius (6.39.12-13), writing in the 2nd century BC, states that an infantryman was issued with the equivalent of 328.5kg wheat per year, or .9kg per day. On P Oxy 2046,[1] dating from the 6th century AD, the daily ration is stated as 1.3kg of bread, according well with Pliny's (HN 18.67) statement that "army bread is heavier by one-third than the grain". On the other hand, Engels (1978, 123-30) has estimated that 1.36kg of grain per day was necessary for each soldier in the Macedonian army, and this is supported by Millett (1990, 57).

The minimum figure of .9kg is preferred here. Unlike Alexander's Macedonian army which was on the march, the soldiers of the North-east were for the most part in garrison. Therefore, not only would they have required less caloric intake, they would have been able to draw upon a wider range of foodstuffs to supplement their daily grain ration than

---

[1] For the translation, see Grenfell and Hunt, 1903-5.

Table 4: Numerical estimates for military animals in the North-east in the Roman period (see Appendix A; Hyland, 1990).

Units in North-east:	Cavalry horses per unit	Total	Other animals per unit	Total
2 units	560	1120	64	128
ala quingenaria				
3 units	1120	3360	128	384
ala milliaria				
7 units	132	924	16	112
equitata quingenaria				
3 units	264	792	32	96
equitata milliaria				
Total number of cavalry horses:		6,196		
Total number of other animals, including draught and baggage animals:				720
Total number of animals:				6,815

Alexander's campaigning army. Indeed, as discussed in the text (6.2.3), the soldiers of the North-east had a remarkably balanced and varied diet. At .9kg per soldier per day, a fort of 480 auxiliaries would have required 4,320kg/day, or 157,680kg/year. At the early 3rd century peak in manpower of 17,000 (Appendix A), forts in the North-east would have required 15,300kg/day, or 5,584,500kg/year of grain.

H-1.2 Animals

In addition to satisfying culinary requirements (discussed in text, 6.2.3), the Roman army in the North-east would have required many animals for transport of materials, as well as in warfare, and each one of these animals would have required fodder. Hyland (1990, 89) has estimated that an ala quingenaria would have required 560 horses and 64 draught or baggage animals, an ala milliaria 1,120 horses and 128 draught or baggage animals, an equitata quingenaria 132 horses and 16 draught or baggage animals, an equitata milliaria 264 horses and 96 draught or baggage animals.[1] As outlined on Table 4, at the early 3rd century peak of manpower (see Appendix A), the military in the North-east would have had to find fodder for at the most 6,815 cavalry horses, and 720 draught or baggage animals, totalling 7,535 animals attached to forts in the North-east.

---

[1] As it is possible that the 'paper strength' of a cavalry unit may have been much less in reality, remounts have not been integrated into the estimates.

Although draught and baggage animals may have required more fodder than cavalry horses when working, the periods over which the former were worked may have been more sporadic than that of cavalry horses. Therefore, the fodder requirements of cavalry horses, which may have been worked everyday (Hyland, 1990), will represent the maximum amount of fodder required for all the animals. On the basis of Polybius' figures, Hyland (ibid, 90) has estimated that cavalry horses required 1.5kg dry weight of barley per day, and at the most (during winter months) 4.5kg of hay per day. In total, 7,535 animals would have required 45,210kg of fodder per day, or 16,501,650kg per year.

H-1.3 Natives

The army's grain demand could have been met from local production only after the grain requirements of the native population had been satisfied. The amount of such 'surplus' grain extracted from the native population is difficult to calculate, as population figures for the North-east in the Roman period are unknown, and because taxation was not imposed uniformly across the provinces. However, taxation of the rural population which was too burdensome could result in depopulation of the countryside and a consequently smaller taxation base. That taxation did not force the native population from the countryside in the North-east during the Roman period is suggested by the great number of native settlements and large body of evidence suggesting extensive cultivation. On the other hand, as discussed in the text (6.2.3), taxation may have been high enough to prevent the accumulation of capital or artefactual

material amongst the native population of the North-east.

Although lack of evidence precludes an accurate estimation of rates of taxation in the North-east, a crude idea can be gained from examination of taxation rates elsewhere in the Roman world. Under Trajan, taxes were generally paid by individual peasants at a rate of one fifth or one seventh their total production (Hyginus, 205). In Africa, land outside the imperial saltus is termed 'octanarius', which suggests that taxation was paid in eighths (Jones, A H M, in Brunt, 1974, 182), while in the late Empire in Bithynia, taxes were paid in tenths (Dio Chrysostom 38.26).

H-2 THE AMOUNT OF LAND NECESSARY FOR GRAIN PRODUCTION

Until recently, it has been assumed that ancient wheat yields were productive of no more than 20 bushels per acre, or 1,413kg per hectare.[1] Indeed, wheat yields in England rarely exceeded 20 bushels per acre before the 19th century (Overton, 1979). However, the Iron Age experimental farm at Butser Hill has thrown new light on the question of ancient wheat yields. On soil without manure or residual nutrient from previous land management, or upon fields left fallow, yields of spelt and emmer reaching nearly 2 tonnes per hectare have been recorded (Reynolds,

---

[1] This yield figure was advanced by Applebaum for the villa at Bignor, Sussex (1975).

1979, 61; 1981).[1] Certain factors suggest that a projection of such yields onto the North-east of the Roman period is not unreasonable.

H-2.1 Climate

As discussed in the text (2.1.2), the climate of the Late Iron Age and Roman period was probably similar to today (Lamb, 1981, 56). On this basis, Haselgrove argues (1984, 9) that modern figures of mean temperatures, annual rainfall and rainfall seasonality, as well as the times of the first and last frosts and the length of the growing season affecting the Butser yields may have been comparable in the late Iron Age - Romano-British periods.

H-2.2 Vitality of the Soil

However, a serious problem with the Butser yields is that the area of cultivation had been under grass for 200 years before the experiment. Even though not provided with residual nutrients from previous land management, the soil nevertheless would have been rich in nutrients, and the yields may be less in 200 years from now (Haselgrove, 1984). This point will be discussed further below (H-3.3). In addition, it is possible that as an experimental farm, the Butser fields may have received too much attention, especially regarding the judicious annual

---

[1] Over eight harvests (1973-80), the yields averaged 1.8 tonnes for spelt, 1.9 tonnes for emmer (Reynolds, 1981).

Table 5: The amount of land under cultivation necessary to meet the grain demands of the Roman army and native population in the North-east (in hectares), based upon known taxation rates of the Roman period.

	Land under Cultivation (hectares)		
	Basic Requirement		
Army's grain demands:			
1. Soldiers	5,584		
2. Animals	16,502		
3. Total	22,086		
Native population's grain demands: (taxation rates applied to '3' above)		Fallow (plus 1/3)	Total
1. Fifths:	110,430	33,463	143,893
2. Sevenths:	154,602	46,849	201,451
3. Eighths:	176,688	53,541	230,229
4. Tenths:	220,860	66,927	287,787

A/91

manuring of the fields. However, no evidence suggests that Romano-British fields were not farmed intensively, and in fact the opposite has been argued (E Scott, 1983, 222). As for fallow fields, if Roman period fields were manured annually, the Butser experiment suggests such crop rotation would have been unnecessary.

In contrast to Applebaum's (1975) figures mentioned above, Manning (1975, 112) cites an example of fields in late 18th century Montgomeryshire, Wales, in an area regarded by contemporary writers as retarded: "a wheat crop... generally yields 20-25 streaks per acre" (Kay, 1794, 17), or a maximum 2,121kg per hectare. Therefore, the Butser yields of nearly 2 tonnes per hectare do not seem unreasonably high.

H-2.3 Estimates

Necessary amounts of seed grain for the following year's crop must be subtracted from the wheat yield totals. Manning (1975, 112) has estimated that such seed grain would have amounted to 1/3 the crop. For our purposes, let us allow for occasionally poor harvests due to early frosts, storms, droughts, and a certain degree of soil degradation, and subtract enough seed grain to reduce the Butser yield by 1/2, following Millett (1990, 57), which would leave ca 1000kg of grain per hectare.

At 5,584,500kg of grain per year, soldiers of the North-east in the early 3rd century would have required cultivation of a maximum 5,584 hectares, while fodder for the animals would have required an additional

16,502 hectares of land either for grazing or for producton of hay and barley. As for the amount of land needed to feed the native population, such estimates depend upon the rate of provincial taxation. The calculations on Table 5 are based on 1000kg grain cultivated per hectare, a maximum 17,000 soldiers and 7,535 military animals in the North-east, that the native population would not have been taxed at a rate higher than 1/5th of the entire year's crop, and the possibility that the fields were left fallow once every three years.

H-3 CAPACITY OF THE NORTH-EAST TO MEET GRAIN DEMANDS

The grain demands of the Roman army in the North-east may have been met partly by local production, though the extent to which this was possible probably varied throughout the Roman period. The pattern of grain production in the North-east could very well follow a three stage model of grain supply set out by Groenman-van Waateringe (1989) for the area along the Lower Rhine. Her model is as follows.

Palaeo-ethnobotanical and zoo-archaeological analyses suggest that during and immediately after the Conquest of the Lower Rhine area, barley was the most cultivated cereal in a mixed farming regime. That bread wheat, the cereal grain preferred by Roman soldiers, was imported is suggested by the lack of evidence for its production in the Lower Rhine during this period, as well as evidence for bread wheat in the period 3 fort at Valkenburg and granary at Neuss, in a well dated to ca AD 90-150 at Butzbach, and in the civilian settlement at Xanten (ibid, 99-100).

By the 2nd century, a wealth of evidence from pollen analyses on civilian sites of the Lower Rhine suggests that the army's grain demands were satisfied by local production. However, the evidence of large amounts of wheat from a 2nd century Roman period ship found near the fort of Woerden suggests that under certain circumstances wheat importation was necessary.

Pollen diagrams indicate a marked decline in cereals from the second half of the 3rd century, and the drop in local wheat cultivation has been attributed to several factors. Wheat cultivation exhausts the land more than any other crop, and consequent soil erosion would have hindered cultivation. Changes in water levels in marine, perimarine and riverine areas rendered the more fertile soils best suited for wheat cultivation unable to support cereal cultivation. Finally, general political unrest in the 3rd century contributed to the decline.

Some aspects of this model recall very closely conditions and circumstances throughout the North-east in the Roman period.

H-3.1 Flavian period

Even though Late Iron Age cultivation was considerable (discussed in Appendix D), the great quantity of grain required by the Conqest army would have strained even the most extensively-cultivated area. Indeed, analyses of charred grain and beetles from a late 1st century context at York indicate importation of grain from Southern Britain or the Continent

at the beginning of the Roman period (Kenward and Williams, 1979), and archaeological evidence suggests that such importation lasted for at least thirty to forty years (Jones, R F J, 1990, 102). This is mirrored at Caerleon, where grain importation has been dated to the early 2nd century (Helbaek, 1964). Imported grain supplies reaching the forts in the North-east during the Flavian period would have been shipped first to ports at York, the Solway Firth, and possibly Berwick-upon-Tweed and South Shields (discussed in text, 6.1.3).

H-3.2 Hadrianic period

However, local production soon may have increased to meet the demands of the army (see Manning, 1975; Jones, R F J, 1990, 100). As discussed in Appendix D, much evidence attests to extensive Roman period cultivation across the North-east. Indeed, most Wall forts and structures were constructed directly over fields which not only had recently been ploughed, suggesting that all of Area 2 had come under cultivation by the Hadrianic period, but which had been ploughed for a long period before the Hadrianic period.

Epigraphic evidence also suggests military purchase or requisition of local grain supplies during or shortly before this period. Foodstuffs mentioned on a Vindolanda writing tablet (Inv. 85/43) are thought to have been gained from the local area (Bowman and Thomas, 1987, 135), while another tablet (Inv. 88/946: discussed in text, 4.4.1) attests to the purchase by Octavius of a large amount (5000 modii) of cereal (spicae and

Table 6: Land under cultivation in the North-east in June, 1990 (in hectares), from MAFF, 1991.

	A: Total Tillage (Crops and bare fallow)	B: Total Tillage and Grass (Excluding rough grazing)
Area 1 (County Durham)	44,349	118,961
Area 2 (County Tyne and Wear)	9,416	15,251
Area 3 (County Nthbld)	89,846	229,171
Totals (Areas 1 and 2):	53,765	134,212
Totals (Areas 1, 2, 3)	143,611	363,383

JK/91

bracis) perhaps again from the local population (Bowman, Thomas, and Adams, 1990, 42).

Although modern agricultural use, especially in the Lowlands and along river valleys, has obscured much evidence of ancient cultivation, it is possible to gain an idea of the extent of Roman period cultivation by examining records of total areas of land under tillage in the modern period. As discussed in Appendix D, since Late Iron Age and Romano-British field systems have been found at altitudes far higher than modern field systems, it is reasonable to assume that not only were the Lowland areas cultivated to at least the same extent, but that cultivation in general was much higher in the Roman than modern period (pers comm P Topping). Therefore, the total area of cultivation in the modern period within the North-east can represent a minimum figure for the total area under cultivation in the Roman period.

As calculated on Table 5, in order to meet the grain demands of the army on a local level, the amount of land which needed to be under cultivation in the North-east was a maximum 220,860 ha, or 287,787 ha if fields were left fallow once every three years. On Table 6, the total areas under cultivation for the three Counties of Durham, Tyne and Wear, and Northumberland are listed for June, 1990 (MAFF, 1991).[1] 'A', the

---

[1] As the County of Tyne and Wear represents less than half of the total area of Area 2, the figures for total area under cultivation in the modern period represent the very minimum of cultivation in Area 2 in the Roman period.

total area under tillage including crops and bare fallow, and 'B', the total area under tillage and grasses excluding rough grazing, respectively, represent the low and high figures for land which may have been under cultivation in the Roman period throughout this survey area. As evidence suggests that cultivation was very extensive throughout the North-east in the Roman period, the higher figure is preferred here. As it is uncertain to what extent Area 3 was exploited for the supply of th Roman army, totals both excluding and including Area 3 are given.

It seems that the maximum amount of land 'B' which could have been under cultivation in the Roman period in Areas 1 and 2 (134,212 ha) would have been well within the maximum amount of land required for the army and its animals at its numerical peak, if the native population was taxed on the basis of 'fifths', and if the fields were not left fallow once every three years (110,430 ha). If Area 3 is included in the calculations, the estimates under 'B' equal 363,000 ha, so that North-eastern production could have met the demands of the army and its animals, as well as the native population taxed on the basis of tenths, with enough surplus for grain exportation, even if fields were left fallow once every three years.

H-3.3 From the Severan to the end of the Roman period

Whether or not grain demands were met on a local level, by the Severan period grain was imported from outside the North-east. Construction of Severan period intra-mural granaries at South Shields, together with their subsequent continuation and expansion in capacity, suggests that this port was an entrepôt for Continental and South British grain, perhaps until the end of the Roman period.

This importation was carried out presumably because the North-east could no longer meet the grain demands of the army. Similar to the Lower Rhineland, the soil may have become exhausted. After a possible increase in wheat cultivation from the Conquest, the North-east by this period would have been exploited extensively for over one hundred years, and it is possible that the soil was spent by the Severan period.

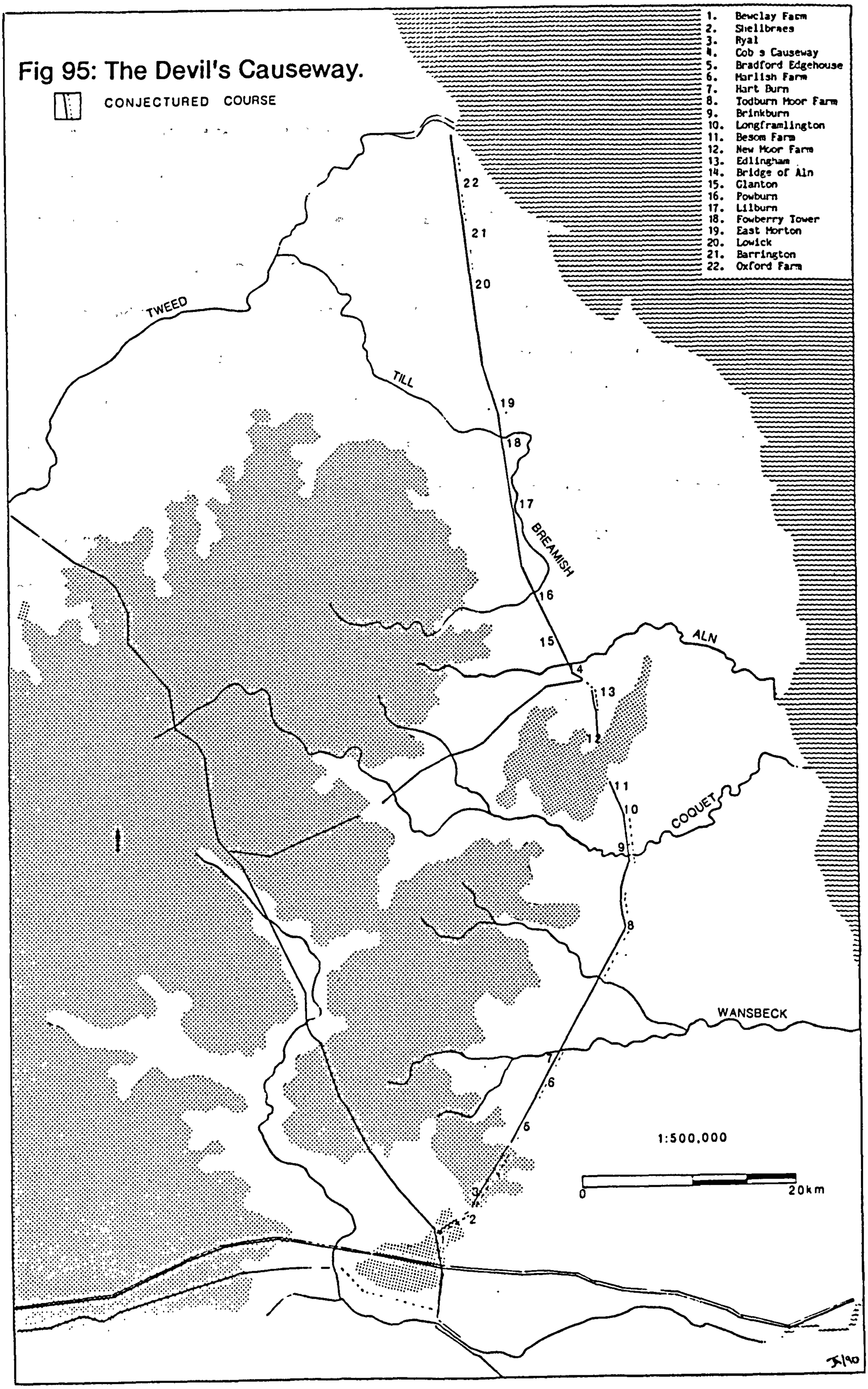
In addition to soil degradation, much of the topsoil would have been washed away into the river systems. As discussed (text, 2.1.2; Appendix D and H-3), extensive cultivation would have rendered topsoil very vulnerable to colluvial erosion. In addition, extensive clearance began in the North-east in the Late Iron Age, and continued into the Roman period. Evidence across Britain suggests that a long period elapsed between initial clearance and eventual alluviation (discussed in text, 2.1.2), and the full impact of such initial clearance may not have been felt until the latter half of the 2nd century. Such processes may have rendered grain production in the North-east much less prolific than it

had been previously.

Although grain shipments from the Continent may have been imported to the North-east at the beginning of the 3rd century, it seems unlikely that such shipments continued for a long period. Indeed, as degradation of soils along the Rhine together with later invasions rendered those grain-producing areas less productive, it may be that after the beginning of the 3rd century the army in this survey area came to rely upon grain imports solely from South Britain. As mentioned in Appendix G-3 and the text (6.1.1), Ammianus' passage attests to grain exportation from Britain to the Rhineland by the 4th century, and evidence for land reclamation in the Fenland and Severn valleys beginning in the 2nd century suggests Lowland Britain was able to supply the North-east with its grain demands.

PAGE NUMBERING AS ORIGINAL

Fig 95: The Devil's Causeway.



Appendix J

THE NATURE AND FUNCTION OF THE DEVIL'S CAUSEWAY

The Devil's Causeway runs through the middle of Area 3, branching from Dere Street at about Bewclay Farm, 2km north of Portgate, 98km north-east to Tweedmouth (see figure 95). It crosses many rivers emptying into the sea, and passes just to the east of Low Learchild fort, about half-way along its course.

J-1 THE NATURE OF THE DEVIL'S CAUSEWAY

Excavations along three sectors of the Devil's Causeway in Area 3 have revealed impressive engineering.[1] In the southern sector (Wright, 1938, 357, 358), the width of the road at Shellbraes was 6.3m, at Cobb's Bank 7.8m, and Edgehouse Farm, 7m. In the middle sector (Wright, 1940a 67, 69, 71: XII, XVII, XXIX, XXXVI), the widths were 5.6m, 6.6m, 6.5m, and 6.6m. In addition, large flat blocks of stone form its foundations.

---

[1] In 1937, Wright (1938, 351-361) excavated seven sections along the southern stretch of the Devil's Causeway and in 1939 (1940a, 65-74), cut a number of trenches between Longframlington and the bridge of Aln. Further north, a section of the Devil's Causeway was uncovered along a .6km stretch during construction on the Newcastle-Wooler road, beginning at Brandon House Farm and ending at Percy's Cross (AMC, 1946-50, 117-18.). Nearby, during Wright's first excavation, Richmond and Askew (1938, 44-50) excavated a number of trenches along the Bremenium-Thrunton cross road connecting Dere Street and the Devil's Causeway about half-way along its length. In the same year, Richmond and Hunter-Blair (1938, 51-2) excavated a section at Holystone on the Bremenium-Thrunton cross road.

In the southern sector the foundation layer at Edgehouse Farm consists of 14cm grade sandstone blocks laid carefully in clay subsoil (Wright, 1938, 354). In the middle sector (Wright's XXIX), 25cm grade sandstone blocks (Wright, 1940a, 69), and in the northern sector a penning of water-worn stones 36cm thick were found (AMC, 1946-50, 118).

The surface layer is also of good quality, set on a camber to allow drainage into ditches cut along the sides. In the southern sector, a number of 7.5cm cubes of sandstone and limestone were discovered at Ryal and Bradford Edgehouse Farm (Wright, 1938, 354). In the middle sector (Wright's VII), 14cm grade sandstone blocks provided the surface, while traces of a gravel topping were found at the bridge of Aln (Wright, 1938, 67,73). In the northern sector, a gravel covering layer was revealed (AMC, 1946-50, 118).

The surface layer is bounded almost always on either side with kerbstones. In the southern sector, 30cm grade sandstone blocks were used (Wright, 1938, 73) and 22.5cm grade sandstone kerbs were found at the bridge of Aln (Wright, 1940a, 69).

In addition, in the middle sector (Wright's XXIX), a central rib projects 14cm above the surfacing (1940, 69), and in Wright's XVII, a rib of flat blocks 25cm by 25cm had been laid along the axis of the road against which bottoming had been packed (1940, 67). The function of this rib is uncertain. Wright argues that it served as a setting-out line where stones were laid outward to either kerb. Although he argues that

the rib in section XXIX may have served as a gauge for the minimum height of the camber (1940, 71), Richmond and Hunter-Blair (1938, 52) felt that a similar rib at Holystone held in place the upper layer of fine stones now washed-off the roadway by storms. Therefore, it may have functioned in controlling movement of the metalling upon this road. If so, because it is of relatively rare occurence throughout the Empire (ibid.), this structure might reflect a special effort made by the engineers to ensure the road's longevity.

The Devil's Causeway has at least one other component setting it apart from most other roads of this type: the almost total lack[1] of an agger - embankments upon which stone foundations were laid. These are thought to have provided a system of drainage for water collected around the foundation layer (Margary, 1973, 19).[2] Consequently, there is often an absence of parallel ditches and pits along the road, from where it is thought earth was excavated to build the agger.

However, the absence of an agger is not shared by the counterparts of the Devil's Causeway in the North-east. Along Dere Street the agger is .9m high north of Corbridge school (Margary, 1973, 476) and slanting up

---

[1] Examples of agger do exist: in the southern sector (Margary, 1973, 478), an agger of 3.46m wide and .19m high has been found in the valley of the Hart Burn, while in the northern section near East Lilburn traces of an agger have been discerned (ibid., 479).

[2] The size of the agger varies in Britain, some having huge proportions. At Roman Ridge, the agger is 10.8m wide and 1.8m high (Margary, 1973, 415), while at Ackling Dyke, it is over 12m wide and 1.8m high (ibid., 104).

the hillside towards Woodhouse (ibid., 477), .6m high at Featherwood Farm north of Bremenium (ibid.), and 8.4m wide just north of the river Coquet (ibid.). On the Bremenium-Thrunton cross road (ibid., 483) the agger is visible almost along its entire length, and is sometimes of large proportions (ibid.).

Two things might explain this. First, unlike Dere Street or the Bremenium-Thrunton cross road, the Devil's Causeway traverses mostly Lowland areas, some sections of which would have provided excellent drainage.[1] Second, perhaps the presence of the central rib on the Devil's Causeway (absent on Dere Street) facilitated drainage in the absence of an agger.

The width and straight course of the Devil's Causeway place it in the category of a Roman military trunk road. As for the time period of its construction, it is argued generally that the bulk of military roads were built from AD 43 to the late 90's. If this is correct, the governor first passing through the region of the Devil's Causeway was Agricola, in AD 79-80. His campaign had reached Strathmore before he was recalled in 84 or 85, and the trunk roads into Scotland and the Devil's Causeway were probably in existence or under construction by then (Hope Dodds, 1940, 67).

---

[1] For example, in the northern area, the road is constructed directly over the sandy soil of the river Breamish alluvia (AMC, 1946-50, 118).

The date of the fort at Low Learchild provides a clue. As the Devil's Causeway and Bremenium-Thrunton cross road are the fort's only communication links to the south, it seems likely that these roads were built at least at the same time as the fort, if not before. Therefore, the date of the first occupation at Low Learchild might provide a terminus post quem for the construction of the Devil's Causeway.

In 1946, Aitchison found 1st and early 2nd century pottery in trial trenches at Low Learchild fort (Taylor, M V, 1947, 167). Pottery of an early 2nd century date was also found in the later of the two forts excavated on this site by Richmond in 1956 (Taylor, M V, 1957, 206). On present evidence, it is argued (E B Birley, 1961, 245) that the second fort did not continue after the establishment of the Hadrianic frontier system, and was most likely abandoned during or just after the Flavian period (pers comm C M Daniels). If indeed the later fort is pre-Hadrianic, the earlier fort would most likely date to the original advance of Agricola.

Fig 96: Ptolemy's Map of Britain, from Ptolemeus Cosmographia Roma, 1478.

J-2 FUNCTION

J-2.1 Penetrating road

Rather than traversing the Pennines and Cheviots through Area 3, the Devil's Causeway branches just beyond Portgate to follow the Lowland area, inhabited during the Roman period by the tribes of the Votadini.[1] The Votadinian oppidum was most likely Traprain Law,[2] and scores of Iron Age and Romano-British settlements have been recovered throughout Area 3. It is likely that the Devil's Causeway penetrated the middle of their territory.

Although most settlements have been recovered in the valleys of the Rivers Till and Breamish and their tributaries in the Cheviot Massif (Jobey, 1965, 57), it is likely that the Lowland areas were as densely-populated and cultivated. Again, recovery rates of Highland settlements are higher because of the greater degree of cultivation across the Lowlands over the millennia (Jobey, 1966). Indeed, it is the better soil of the Lowland areas which will be cultivated before the

---

[1] In about 160 (Hope Dodds, 1940, 65), Ptolemy (Geog 2.3.7) placed the Votadini on the North Sea side (south on Ptolemy's map, see figure 96) of Bremenium (High Rochester), and between the Rivers Albanus and Vedra. Although modern equivalents are much-debated, two candidates are the Firth of Forth and Wear respectively.

[2] Artefactual evidence suggests that after a Neolithic habitation and subsequent abandonment at Traprain (Curle and Cree, 1915-23) occupation of this very large site resumed during the 1st century BC or early 1st century AD (Jobey, 1976, 194).

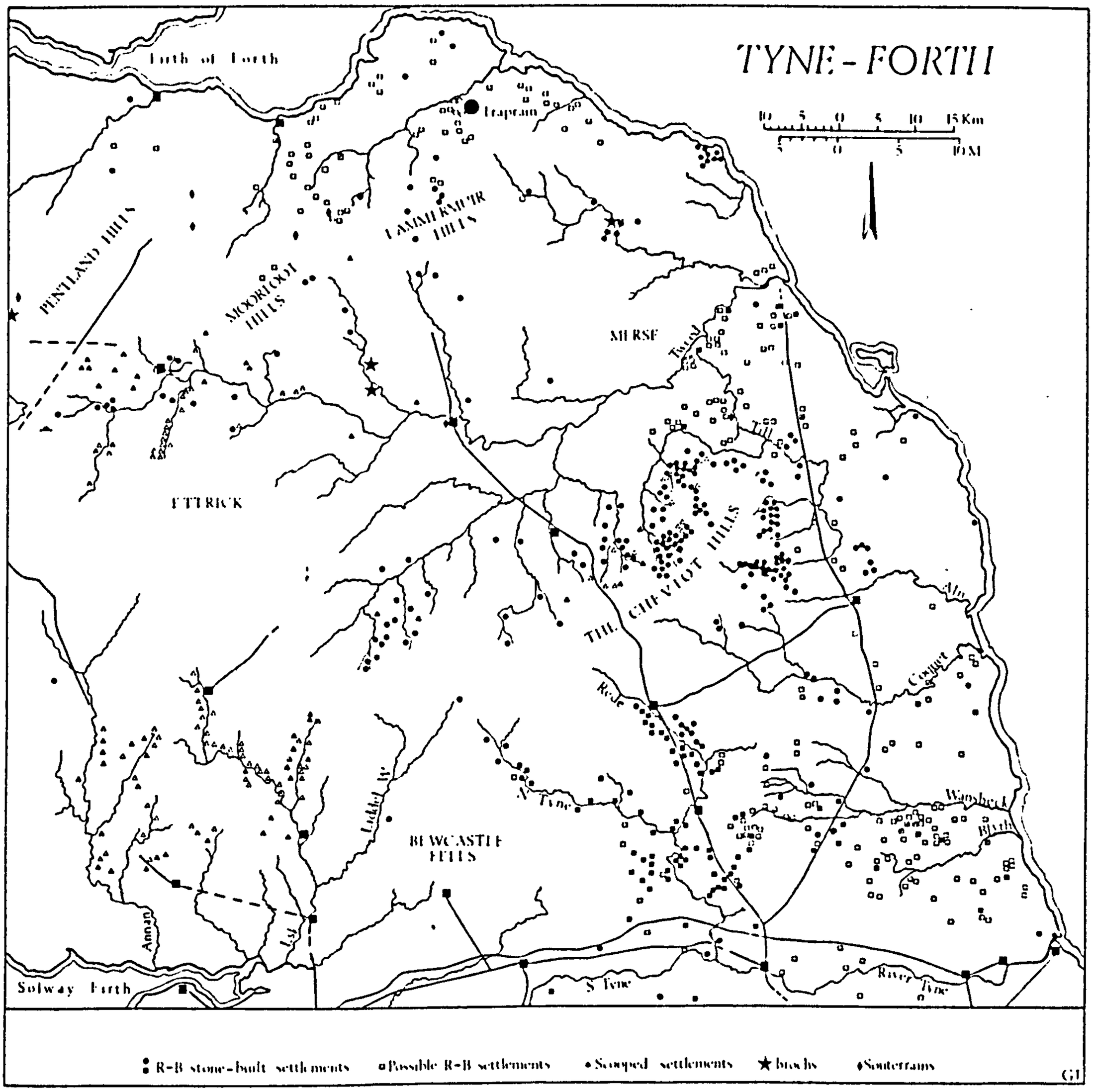


Fig 97: Settlements in the Tyne-Forth area, from Jobey, 1982, fig. 8.

acidic, marginal lands of the Highland Fell sandstone. Therefore, the course of the road likely reflects the desire to penetrate through this area of heavy settlement. The Votadini, at least at first, were an 'enemy' which needed to be pacified. Agricola's was a campaign of conquest, and he may have thought a road necessary to secure the eastern flank of the main trunk route into Scotland, and a life-line with the south - Dere Street.

In this way, the Devil's Causeway would have functioned the same way as the road constructed north from York, through Chester-le-Street to the Wreckendike. Both roads parallelled Dere Street, and traversed densely-populated Lowlands. In addition, both roads were garrisoned by only one fort.

It has been suggested that the road from Chester-le-Street would have crossed the Tyne at Newcastle over an early bridge, and continued through to a bend in the Devil's Causeway in the region of Netherwitton as many Roman period rectilinear constructions found in this area could be construed as military installations servicing a road (Hafemann, 1956, 149-156). However, the rectilinear constructions in this area have been identified as native settlements rather than forts (Jobey, 1973, 52). Alternatively, St Joseph (1969, 105) has suggested another road running south of the Devil's Causeway at a point where it changes direction from north-east to north-north-east, crossing the river Pont at about Woodhouse, ca 700 yards (630m) west of the two supposed Roman forts at Longshaws. However, if a line was drawn following the same course as the

Devil's Causeway south of the direction change, as St Joseph has done, it would bring the road 11 degrees to the east of the crossing at Woodhouse (Jobey, 1973). In any event, no trace of either road has been found on the ground. Rather, it seems that the road running north from Chester-le-Street terminated at the Wreckendike, and the Lowland penetration road east of Dere Street - the Devil's Causeway - was continued north of Portgate after the Tyne crossing at Corbridge.

J-2.2 Supply road

The Devil's Causeway may have functioned as a supply medium, over which sea-borne supplies could have been transported to troops further inland. However, if constructed primarily as such, the road should run east-west along a river valley to the sea from Dere Street, rather than traversing the length and breadth of Area 3 before reaching the sea. It has been suggested that a road ran eastwards from the Devil's Causeway to Warkworth near the mouth of the Coquet (HBNC, 1856-62, 86). This theory rests upon the discovery of the Campestres altar at Gloster Hill a little south of Warkworth, set up by an equestrian cohort,[1] and place-names suggesting Roman period roots. Margary (1973) has suggested a road continuing west from the Bremenium-Thrunton cross road where it meets the Devil's Causeway, as far as Alnmouth. Finally, Selkirk (1987, 114) suggests a road continuing in a north-eastern direction beyond the

---

[1] Collingwood and Wright, 1965, RIB 1206:
"(Ca)mpestri (bus c) oh (ors) I (...) To the Goddesses of the parade ground...the First Cohort".

Devil's Causeway where it changes direction to north-north-east as far as Alnmouth. However, no archaeological evidence attests to these roads.

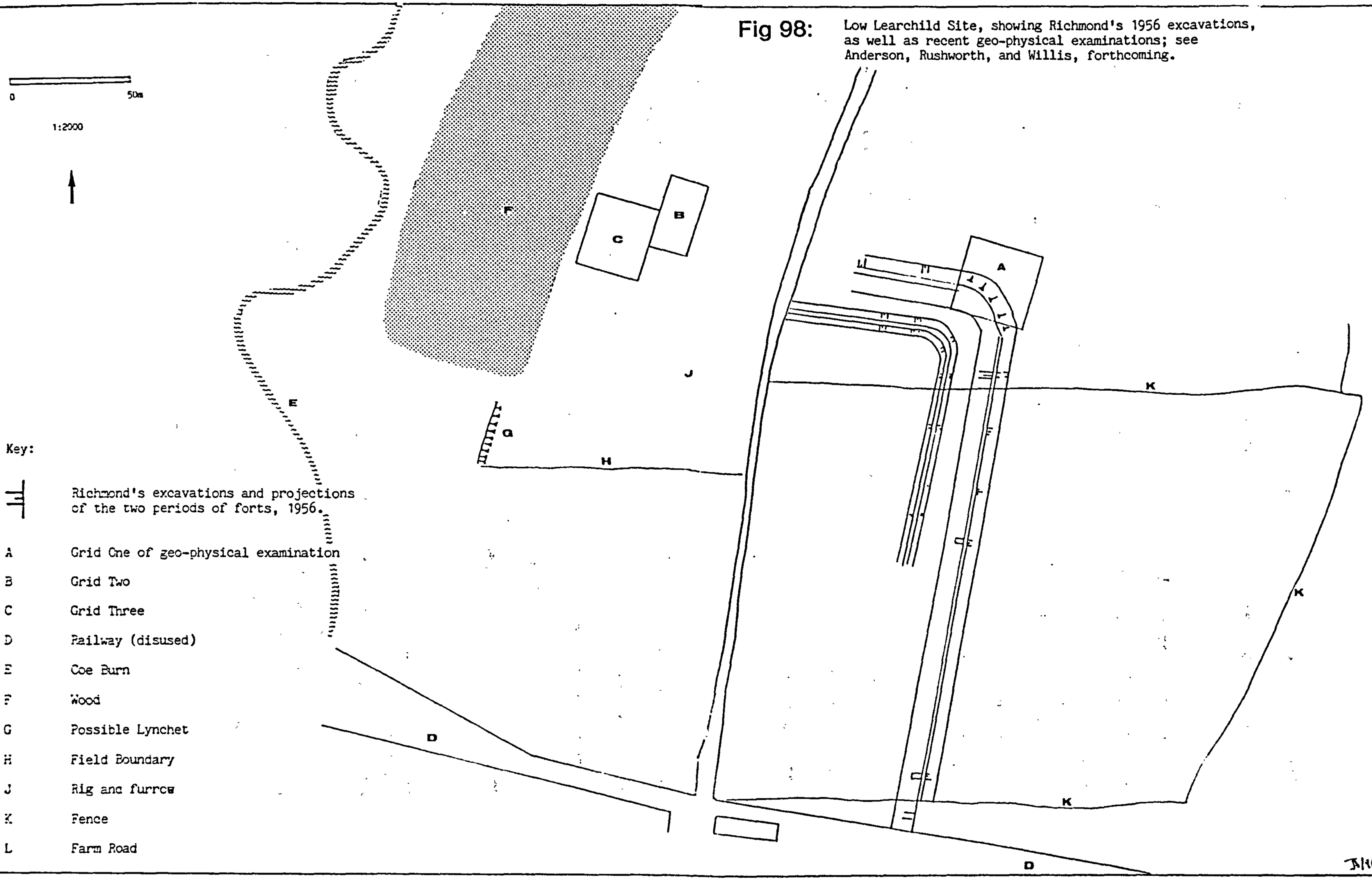
In the apparent absence of such east-west roads, the primary reason for the Devil's Causeway, therefore, must have been in order to penetrate Area 3. However, the fact that the road terminates at a river mouth nevertheless suggests that once constructed the road may have served as a supply medium to a certain extent. Indeed, as discussed in the text (6.1.3), the well-known passage from Tacitus (Agric., 25.1) suggests that Agricola may have used this road in order to keep in contact with the fleet. Communications and supply from Berwick-upon-Tweed to Dere Street would have been facilitated once the Bremenium-Thrunton Cross road had been constructed.

That this road functioned as a supply medium may explain the provision of only one known fort along its length.[1] Indeed, a continuous chain of garrisons may have been deemed unnecessary, as only a minimum level of protection was required for people travelling or materials transported. The garrison at Low Learchild, situated near the intersection of the Devil's Causeway and Bremenium-Thrunton cross road, may have been a

---

[1] Not one of the nine sites MacLauchlan (1864) named as Roman stations are still considered forts. Excavations have proven otherwise at Ferney Chesters (NEECR, 1924-5, 8) while for various reasons Brinkburn, Bolam, Crawley tower, Newtown, Belford, Outchester, and Spindlestone Heugh no longer are considered Roman forts or fortlets (OS). Although St Joseph has listed potential sites from aerial photography, Hart Burn and Mitburn (Jobey, 1973, 51), as well as Tweedmouth (St Joseph, 1969, 105) have since been identified as Roman period settlements.

Fig 98: Low Learchild Site, showing Richmond's 1956 excavations, as well as recent geo-physical examinations; see Anderson, Rushworth, and Willis, forthcoming.



Key:

	Richmond's excavations and projections of the two periods of forts, 1956.
A	Grid One of geo-physical examination
B	Grid Two
C	Grid Three
D	Railway (disused)
E	Coe Burn
F	Wood
G	Possible Lynchet
H	Field Boundary
J	Rig and furrow
K	Fence
L	Farm Road

sufficient force to carry out the protection of this supply/communication link.

It is argued (E B Birley, 1961, 245) that the later fort at Low Learchild was large enough to hold a cavalry regiment. From aerial photography, St Joseph reckoned (1955, 56) its dimensions over the ditches at 800x600 feet [240x180m]. After 1956 excavations, Richmond wrote:

> "... the earlier [fort]... was defended by two double ditches, 8 ft [2.4m] wide and 8 ft [2.4m] apart, which had been deliberately filled with turf. The east side was at least 250 ft [75m] long and the north at least 130 ft [39m] long. The later fort... had an east side at least 760 ft [228m] long and a north side at least 250 ft [75m] long. It was defended by a single ditch 15 ft [4.5m] wide and a clay rampart 23 ft [6.9m] wide."
>
> Richmond in Taylor, M V, 1957, 206

In April, 1991, a geo-physical excavation was carried out over three grids above the ramparts of this fort in order to further elucidate the dimensions of the ramparts (see figure 98). Briefly (see Anderson, Rushworth and Willis, forthcoming), the north rampart, picked up in the north-east corner of the outer fort, continues west on the same alignment across the farm track, and through grids 2 and 3 (see figure 98). The north rampart measures at least 170m, the north-west corner of which lies somewhere in the modern wood (see figure 98). The results of this examination bear out St Joseph's estimations, and reveal a fort of extraordinarily large dimensions: indeed perhaps housing a cavalry regiment.

That this road did not continue as a supply medium beyond the beginning of the 2nd century is suggested by the abandonment of Low Learchild at this time. Indeed, the lack of forts along its length suggests against a role in the Hadrianic Wall system, and from this period to the end of the Roman period, with the exception of the Antonine Wall interlude, the Devil's Causeway remained outside the province. Further, once South Shields had become a major port, the forts in Area 3 could have been supplied overland from South Shields and Corbridge faster than from Berwick-upon-Tweed via the Devil's Causeway (see Table 2).

J-3 CONCLUSION

The Devil's Causeway was constructed most likely under Agricola primarily as a road of penetration into the land of the Votadini, and may have functioned also as a communication/transportation link between the fleet and the army. However, its course across the length and breadth of Area 3 and termination at Berwick-upon-Tweed suggests that supplies would have been obtained from ships at the mouth of the Tweed, and not along rivers developed with or in lieu of Piercebridge formula components.

The road likely fell out of use as a supply medium for sea-borne supplies by the beginning of the 2nd century. However, given the evidence for trade between the army and Votadini, it is possible that the Devil's Causeway continued to be used to a certain extent throughout the Roman period as a supply medium for transport within Area 3.

Appendix K

THE LOGISTICS OF RIVER NAVIGATION ABOVE THE TIDAL LIMITS

As discussed in the text (6.3.3), navigation during the Roman period along North-eastern rivers above their tidal limits may have been facilitated to some extent either by river improvement, or by simply avoiding obstacles obstructing the channels. Following is an elaboration of these possible measures.

K-1 RIVER IMPROVEMENT

Eckholdt (1984, 4) has described various ways in which small rivers could have been improved to facilitate navigation in Central Europe in the Roman period. First, sharp bends and individual obstructions to ships such as large rocks and dislodged trees would have to be moved manually. Shallow waters could have been deepened in one of two ways. First, 'gravel ploughs' such as those used until 1875 for deepening the River Weser may have been used. These rake-shaped implements drawn over gravel banks by means of horses or windlasses pushed gravel to the sides. On other rivers, the current would carry away the sediment if the bed was merely loosened. Second, the current could be concentrated by rows of oars, driven vertically into the bottom, to form a narrow channel, thus generating a strong rush of water in its course which would remove the gravel.

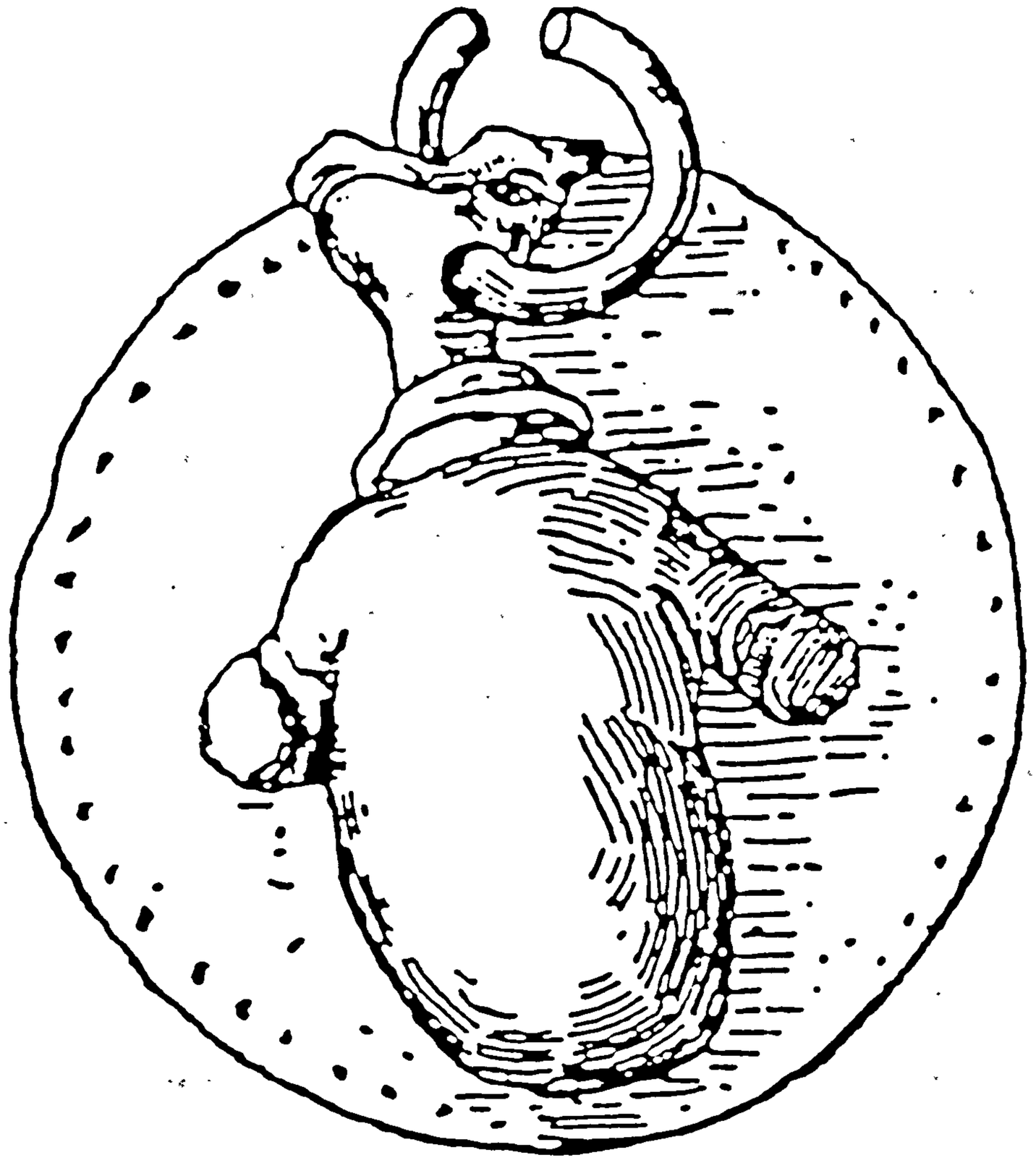
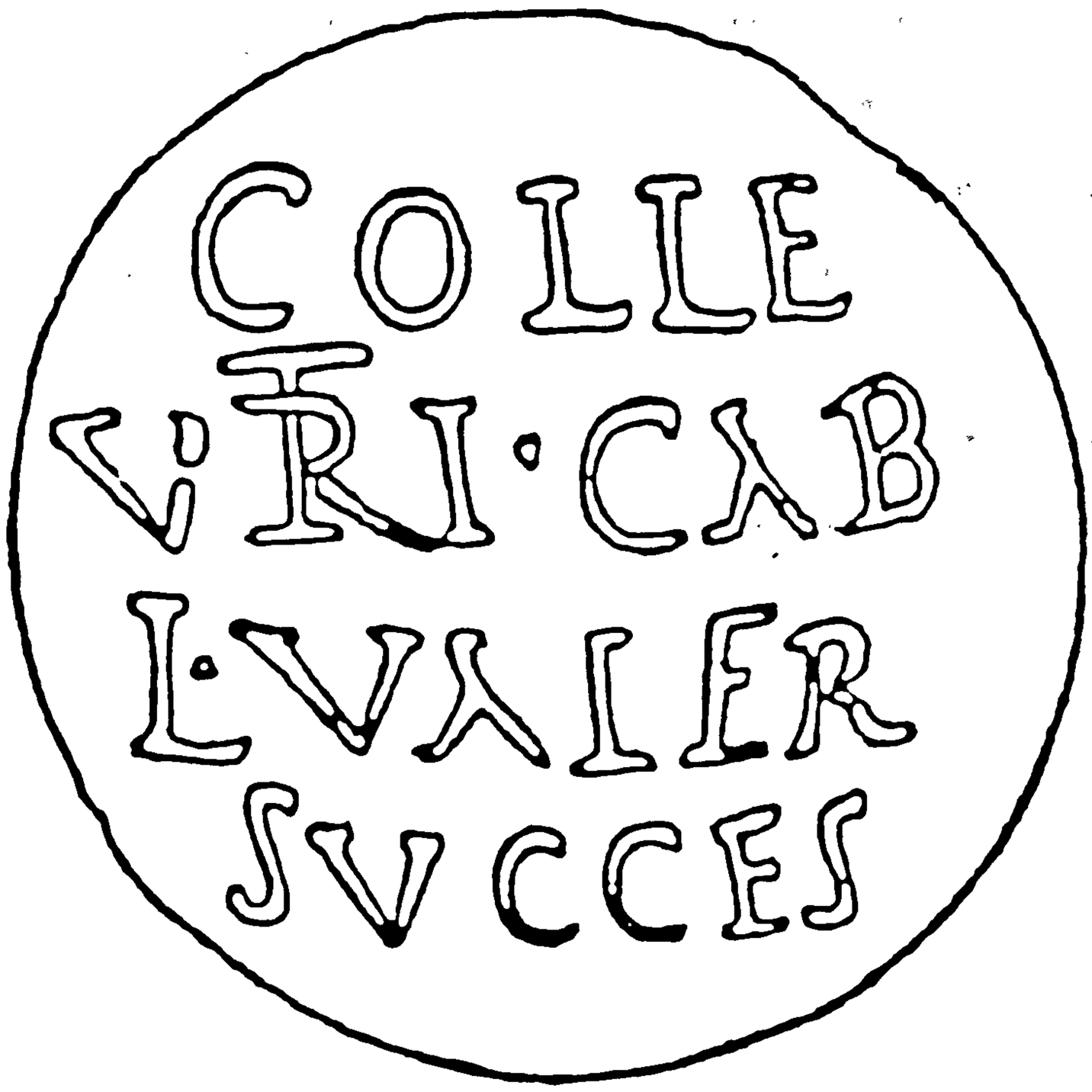


Fig 99: Flotation Bladder on Medallion, from Johnstone, 1980.



K-2 FLOTATION DEVICES

Alternatively, river barges could have navigated over shallow courses with the addition of flotation devices. The badge of the Utricularii shows an inflated goatskin, suggesting that craft were made lighter by such a device (see figure 99; Johnstone, 1980).

K-3 PORTAGE

Goods could have been carried around obstacles in the river systems. As mentioned in the text (6.3.2), this was carried out with collapsible boats at the last of the Nile cataracts above Aswan in the ancient period (Pliny the Elder, HN, 5.10.58).

The logistics of large-scale portage are well-recorded for the modern period, especially with regards to that carried out across Western Canada by employees of both the North-west and Hudson's Bay Company in the 18th and 19th centuries. Indeed, both cargo and canoes would often be carried around obstacles in rivers, sometimes 20km at a time. Bales of supplies carried by les Voyageurs and the natives varied in size, but always weighed 40.5kg.[1] Each crew member would tuck one of the bales into the small of his back, part of its weight borne by a leather trumpline stretched across his forehead so that some of the strain could be

---

[1] Voyageurs could earn a Spanish silver dollar by carrying an extra bale to speed the portage crossing (Newman, 1988, 38).

absorbed by neck muscles. His partner would settle another bale between the carrier's shoulder blades, and "the loaded man would dogtrot along the portage trail, knees and back bent, legs pumping, arms swinging free" (Newman, 1988, 37).

K-4 TRANS-SHIPMENT

Alternatively, once rivers became unnavigable, supplies could have been trans-shipped onto carts and transported to forts over the road systems. An example of such trans-shipment above the tidal limit of a British river may be at Heronbridge, Cheshire, where remains of Roman period buildings and docking facilities have been found along the River Dee and Watling Street (see figure 100).

First, river transport down the Dee to Heronbridge seems likely. About 19km upriver were the tileries and kilns of the Twentieth Legion at Holt. Holt is situated in an area abundant in good quality clay and timber, and close to the river (Mason, 1988a, 178). Along with ceramics, raw materials from Holt were probably used at Chester fortress, 2km downriver from Heronbridge.

Second, the location of Heronbridge suggests a 'staging' or 'transfer' point. Just north of Heronbridge the river becomes shallow and rocky, and generally unsuitable for river traffic (Thompson, 1965, 16). In addition, the site is situated at a point where the Dee runs very close to Watling Street.

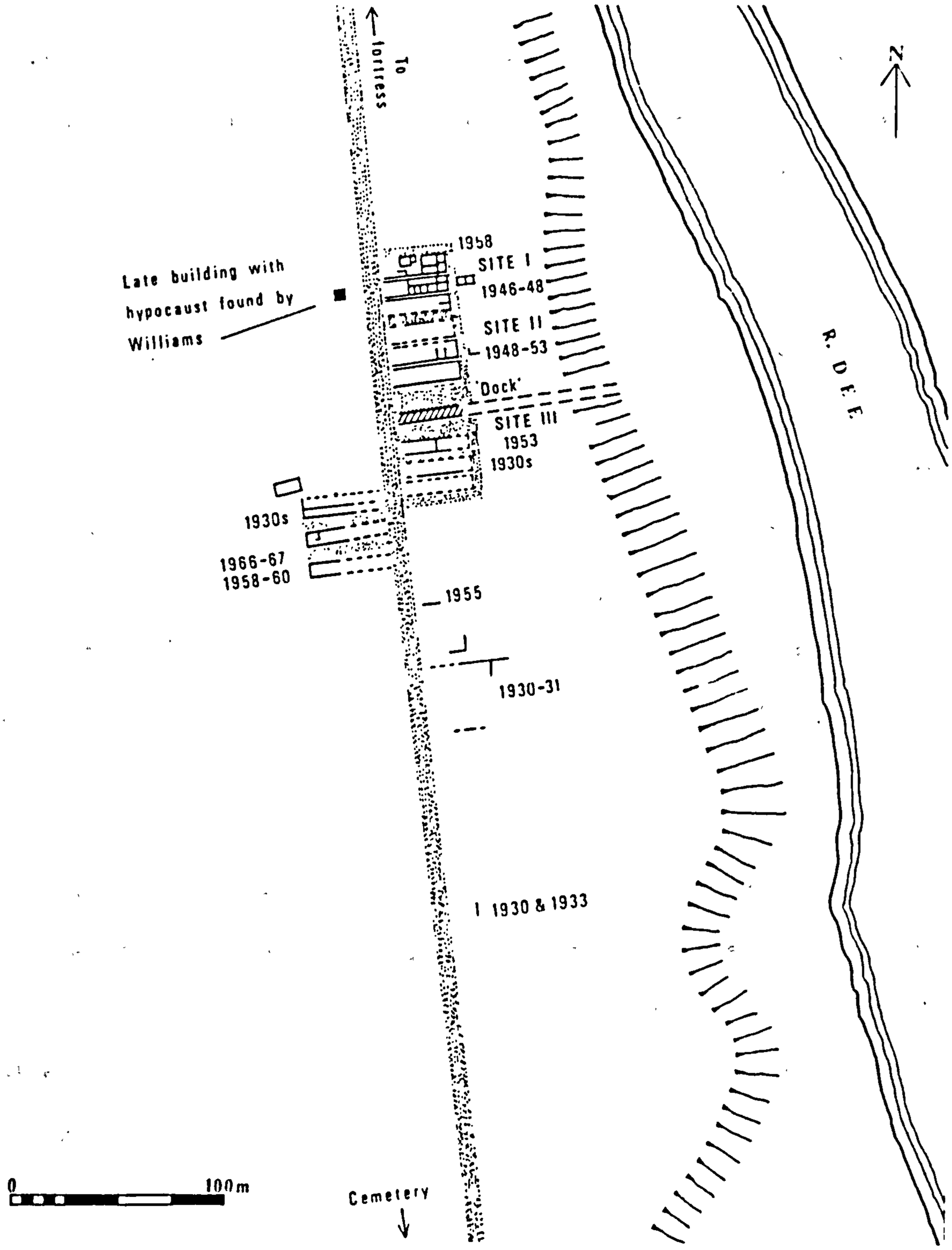


Fig 100: Roman Heronbridge: stone buildings, Hadrianic and later, from Mason, 1988b, 125.

Third, overland transport of goods along Watling Street from Heronbridge is suggested by buildings found straddling either side of the road. The buildings on the east side of Watling Street occur for a distance of over 210m, and 60m on the west. In the first occupation period - AD 90-130 - evidence exists for industrial activity, such as bronze-working.[1] From about 130, considerable rebuilding in stone took place. The buildings have been interpreted as commercial premises or more specifically, storehouses (Thompson, 1965, 62) belonging to a civilian population (Mason, 1988a, 176). The buildings were either lean-to sheds or more substantial structures partitioned internally into rooms, placed on east-west axes and in groups of three or four, separated by lanes, long and narrow in plan, ca 9m wide, 30m long. The western aspect of the buildings may have served as repositories for goods while the rooms at the eastern aspect may have been living quarters for store-keepers and their families (Thompson, 1965, 62).

Therefore, it seems that ceramics and raw materials could have been supplied to Chester from Holt via river barge to Heronbridge, at which point the supplies were trans-shipped directly onto carts or pack animals for transport along Watling Street, or stored in warehouses for future overland delivery (Hartley et al, 1954, 14).[2]

---

[1] An open-ended timber shed with a hearth of a bronze-smith's shop has been identified from evidence of bronze slag, clay crucibles and moulds.
[2] For an alternative interpretation of the function of Heronbridge, see Mason, 1988b.

Appendix L

HISTORICAL PARALLELS TO ROMAN PERIOD RIVER TRANSPORT IN THE NORTH-EAST

At least three successive periods may shed light on transport along North-eastern rivers during the Roman period.

L-1 MEDIEVAL PERIOD

The Late Medieval period marks the first point at which significant activity can be traced along North-eastern rivers after the Roman period. Shipping lists of the 14th century attest to vibrant commerce carried out along the River Tyne between its mouth and Newcastle. However, by this period, significant differences had occurred in river-borne transport from what is known of Roman period river transport. Indeed, the people of Newcastle kept a tight rein on trade along the Tyne. Writes Fraser (1961, 143):

> "North Shields had not yet recovered from the legal proceedings taken against it in 1290-2. Nearby Gateshead was watched with unflagging vigilance lest the Bishop of Durham gain the benefits of a Tyne quayside without payment of dues to the commonality of Newcastle... The prior of Durham was not allowed to land his own wool from Holy Island on the south bank of the Tyne. Newcastle burgesses had attempted to monopolize the whole of the profits of the Tyne bridge although its southern end necessarily was built on the bishop's land, and even disputed the right of the bishop to hold an inquest on drowned persons found in the southern stretch of water adjacent to his lands... The claims of Newcastle to be the sole mart on Tyneside for all commodities except salt and herring were sanctioned by a tradition nearly two centuries old".

Furthermore, commissions were issued in 1331 to prevent wool being loaded

in "divers places by the sea-coast" in Northumberland without paying custom (Blake, 1965, 247). In 1392, commissions were given to Thomas Etton and John de Mitford to check the loading and unloading of goods between the sea and the port of Newcastle, and to cause proclamation to be made that no merchant should load or unload except at the quay of Newcastle (ibid., from Cal.Cat.Rolls, 1330-3, 318; 1392-6, 102).

These divisions and rivalries are unlikely to have existed in the Roman period. A law dating from the time of Hadrian (Webster, 1988, 140) ensures the right to the free use of rivers:

> "The right to use river banks in public by jus naturale just as is the use of the river itself. And everyone is at liberty to run boats aground on them, to tie ropes on to trees rooted there, to dry nets and haul them up from the sea, and to place any cargo on them, just as to sail up or down the river itself."
>
> Justinian Digest (Gaius) 1.8.5

In addition, it is likely that traders in the Medieval period were much more dependent upon the Tyne than in the Roman period. Indeed, because of the horrendous state of the roads, rivers in the Medieval period constituted the most important means of inland transport (Pratt, 1912, 15). Before the turnpike era, the maintenance of roads fell to the church, and the "keeping of roads in repair came to be considered a pious and meritorius work before God, of the same sort as visiting the sick and caring for the poor" (Jusserand, 1889).[1]

---

[1] The frequent funds within his episcopal register suggests that Richard de Kellawe as Bishop of Durham (1311-1316) may have forgave part

Prior to Aire and Calder being made navigable, in the area of Leeds:

> "The roads were sloughs almost impassable by single carts, surmounted at the height of several feet by narrow horse-tracks, where travellers who encountered each other sometimes tried to wear out each other's patience rather than either should risk a deviation. Carriage of raw wool and manufactured goods was performed on the backs of a single horse, at a disadvantage of nearly 200 to 1 compared to carriage by water.
>
> Whitaker, 1846

On the other hand, Roman roads were constructed and maintained by a central administration to a very high standard. Indeed, as discussed (Appendix J-1), the high quality of these roads has been attested by numerous excavations across the North-east. Therefore, it is likely that trade was much less focussed along navigable rivers in the Roman than Medieval periods in the North-east. In total, Medieval transport along North-eastern rivers does not represent an adequate parallel to Roman period river-borne transport in the North-east.

---

[1] (cont'd)of the penalties on the sins of those who contributed to road work.

L-2 18TH CENTURY

Transport in 18th century England has been used as a parallel to transport in Roman Britain. Duncan-Jones (1974) compares his ratio of sea, river, and land transport of the Roman period to the same ratio for 18th century England.

Roman period: sea : river : land = 1 : 4.9 : 28
18th century England: sea : river : land = 1 : 4.7 : 22.6

This parallel is used further by Salway (1984, 563), who compares 18th century canals serving the Staffordshire pottery trade which were able to charge as little as fifteen per cent of the former cost by road. Gillam and Greene (1981, 9) state that it cost as much to carry a given quantity of coal by road from West Auckland in County Durham to Tyne Dock in Tyne and Wear, a distance of 42km, as it was to carry the same quantity by sea from Tyne Dock to London, a distance of 584km, 14 times the cost per km.

However, applying this ratio to the Roman period North-east is problematic. First, as discussed in the text (2.2.3), Duncan-Jones' ratio, based upon transport costs derived from Diocletian's Edict, is very likely inflated: Roman period road transport in the North-east would have been much more economical.

Second, North-eastern roads of the Roman period would have been much better than those of the 18th century. Indeed, roads do not seem to have improved much in this area from the Medieval period: Defoe's description (discussed in text, 2.1.2) of the abominable state of 18th century roads

across the North-east stands in stark contrast to the evidence for the excellent state of roads across the North-east during the Roman period. Indeed, by the mid-19th century, better-constructed turnpikes built across County Durham rendered immediate access to a river less important than previously (Kirby, 1972, 275). Likewise, the high quality roads of the Roman period may not have warranted the development of river systems.

In addition, as discussed in the text (2.1.2), the combined effect of geo-fluvial processes such as floods and siltation rendered the rivers of the North-east 'un-improvable' by water engineers of the 18th century, while rivers in Southern England underwent considerable development. Therefore, a comparison between southern rivers in 18th century with those of the North-east, and roads of the Roman period with those of the 18th century is invalid: transport along Roman roads may have been much easier than along the undeveloped Roman period rivers of the North-east.

L-3 19TH CENTURY KEELMEN

Keelmen, rowing or sailing keel-boats loaded generally with coal between the collieries along the Tyne and the ocean-going cargo ships further down the Tyne have been parallelled with Roman period bargemen in the North-east (see Richmond, 1953).

Indeed, similar to the Roman period, and unlike the Medieval period, no petty divisions of ownership and hegemony existed along the Tyne. The only restrictions seem to have been those imposed upon them by the

collieries, which stipulated that keelmen were not permitted to sell coals to other people (Mitcalfe, 1937, 4). In addition, Keelmen were 'bound' by a contract to the fitters for one year, and were liable to severe penalties if they left their employment.[1] Therefore, similar to bargemen based in South Shields in the Roman period, the Keelmen of the 18th century were generally without legal restrictions.

Second, there are striking similarities in the types of boats used along British rivers of both periods. As discussed in the text (6.3.1), the Late Iron Age Hasholme log-boat had a light draught and excellent stability, and measured 12.78m long, 1.4m beam, and 1.25m high. It was flat-bottomed, had a rounded bow, a transom stern, and could carry 8,902kg of grain. Similarly, a keel-boat, although carvel built, had a light draught with stem and stern alike, and an open hold in the middle. Similar to the Hasholme, their standard size was 12m long, 4.65m wide, 2m high. However, able to carry a 'keel', or 19,090kg (21 tons, 4cwts), the boats could carry much more weight than the Hasholme log-boat. Keel boats were propelled by a forward oar worked by two keel bullies and a Pee-Dee, and an oar at the stern for rowing and steering, or were sometimes poled, or even sailed (Mitcalfe, 1937, 4).

Third, a unit of bargemen was stationed at South Shields, while the

---

[1] Public notices were exhibited when this occurred, giving particulars of the "wanted men" (Mitcalfe, 1937, 4).

keelmen of the 19th century lived in Sandgate, Newcastle.[1] The keelmen formed a close unit, and petitioned on more than one occasion to become a company.[2] In addition, they gained a reputation for their skills. They have been described as "more robust than any other tribe in England", and when they were on strike, sailors found it impossible to manage the keels and do the necessary work even with extra help (MacKenzie, 1825). Similarly, as discussed in the text (4.1.3), bargemen were transferred from their home in the Tigris river region to South Shields most likely because of their special lighterage skills.

However, this parallel is problematic. First, as discussed in the text (6.3.1), the river conditions were much less conducive to river-borne transport within the tidal limits of the Tyne in the Roman period than during the age of Keelmen. Second, extensive transport may have been carried out along the river systems in the latter period because no viable alternative existed: conversely, excellent Roman period roads were constructed across the North-east. Thus river transport in the Roman period along these rivers may have been more difficult than along the road systems.

Third, and perhaps most importantly, Keelmen carried coal from collieries downriver to ships waiting at the river's mouth. Even so,

---

[1] The keelmen intermarried to a large extent and formed a distinct community apart from the rest of the inhabitants of Newcastle (Mitcalfe, 1937, 2).
[2] They failed in their attempts.

many difficulties were met with the tides, wind, sand and gravel shoals (Chapman, W, 1795b, 10; Whitworth, 1797a, 7; 1797b, 93; Dodd, 1795, 21). Conversely, bargemen of the Roman period would have navigated the Tyne with cargoes upriver. The problems with tides, winds, and shoals would have been much greater moving against the current than down.

Appendix M

ANCIENT SOURCES

Abbreviations

Ann	Annals
Anon	Anonymous
AJ	Antiquitates Judaicae
B Civ	Bello Civile
B Gall	De Bello Gallico
Build	Buildings
Codex	Codex Theodosianus
De Arch	De Architectura
Dig	Digesta
Epist	Epistles
ERM	Epitoma rei militaris
Geog	Geography
Hist	Histories
HN	Historia Naturalis
Met	Metamorphoses
Orat	Orations
P Oxy	Papyrus Oxyrhynchus
Sat	Satires
SW	Selected Works
Tra	Epistulae ad Traianum

Ammianus Marcellinus
Works, translated by John C Rolfe, London: William Heinemann, 1971, in three volumes.[1]

---

[1] Passages cited in the text from ancient authors have for the most part been borrowed from modern translations of the original Latin or Greek. However, when a specific translator is not mentioned below, such texts have been translated by the author of this thesis.

Anonymous
Notitia Dignitatum, edited by Otto Seeck, Frankfurt: Minerva, 1962.

Papyrus Oxyrhynchus 2046, translated by B P Grenfell and A S Hunt, London, 1903-5.

Apuleius
Metamorphoses, translated by Alexander Scobie, Hain: Meisenheim, 1975.

Bede
Ecclesiastical History of the English People, translated by C Colgrave and R A B Mynars, Oxford: Oxford University Press, 1969.

Caesar, C J
De Bello Civile, translated by W A MacDevitt, London: Henry G Bohn, 1851.

De Bello Gallico, translated by W A MacDevitt, London: J M Dent, 1923.

Cassius Dio Cocceianus
Roman History, translated by Earnest Cary, Cambridge Massachusetts: Harvard University Press, 1970, in nine volumes.

Cato, Marcus Porcius
De Agricultura, Heidelberg: Winter, 1978.

Cicero, Marcus Tullius
De Oratore, translated by H Rackham and E W Sutton, London: Heinemann, 1942.

De Lege Agraria, translated by H Rackham and E W Sutton, London: Heinemann, 1942.

De Legibus, translated by M L Leenheer-Braid, Amsterdam: Hakkert, 1972.

Columella, Lucius Junius Moderatus
De Agricultura, translated by Harrison Boyd Ash, London: Heinemann, 1941-55.

Dio Chrysostom
Works, translated by J W Colhoon, London: Heinemann, 1932.

Diocletian
Edict on Prices, in The Transport of Staples, Budapest: Eighth International Economic History Congress, 1982.

Diodorus Siculus
Works, translated by C H Oldfather, London: Loeb Classical Library, 1944.

Fronto, Marcus Cornelius
Ad Verum Imperii, Lipsiae: Teubneri, 1867.

Hero
Automata, Lipsiae: Teubneri, 1919.

Horace
Epistles, translated by E P Morris, Oklahoma: University of Oklahoma Press, 1974.

Hyginus
Liber de munitionibus castrorum, Leipzig: S Hirzel, 1887.

Josephus, Flavius
Antiquitates Judaicae, Frankfurt: Klostermann, 1934.

Justinian
Digest, translated by Alan Watson, edited by T Mommsen, P Krueger, A Watson, Philadelphia: University of Pennsylvania Press, 1985, in four volumes.

Juvenal
The Satires, translated by Lewis Evans, London: G Bell, 1914.

Libanius
Selected Works, translated by A F Norman, Harvard: Harvard University Press, 1969.

Pliny the Elder
Historia Naturalis, translated by Rackman and Jones, London: Loeb Classical Library, 1944.

Pliny the Younger
Epistulae ad Traianum, translated by Betty Radice, London: Heinemann, 1975.

Plutarch
The Lives of the Noble Grecians and Romans, translated by E Dryden, London: Encyclopaedia Britannica, 1952.

Polybius
The Histories, translated by Evelyn S Shuckburgh, London: Macmillan and Company, 1889.

Pomponius Mela
Chorographia, translated by R Ranstrand, Gothenburg, 1971.

Procopius of Caesarea
Buildings, translated by H B Dewing, London: Heinemann, 1968.

Gothic War, translated by H B Dewing, London: Heinemann, 1968, in two volumes.

Ptolemy
Geography, map in "Ptolemaeus Cosmographia Roma 1478", Amsterdam: Theatrum Orbis Terrarum Ltd, 1966.

Strabo
Geography, translated by H L Jones, London: Loeb Classical Library, 1923.

Suetonius, Tranquillus
The Twelve Caesars, translated by R Graves, London: Penguin, 1957.

Tacitus, Cornelius
Annals, translated by A J Church and W J Brodribb, London: Encyclopaedia Britannica, 1952.

Histories, Lyon: Sesthoff, 1966.

The Agricola, translated by H Mattingly, London: Penguin, 1970.

Theodosius
Codex Theodosianus, translated by C Pharr, Princeton University: Princeton University Press, 1952.

Themistius
Orations, edited by H Schenkl, Lipsiae: Teubneri, 1965.

Varro
De Re Rustica, New York: G Olms, 1983.

Vegetius
Epitoma Rei Militaris, edited by Lang, Lipsiae: Teubner, 1895.

Vitruvius Pollio
De Architectura, translated by Frank Granger, London: Heinemann, 1931-4.

Appendix N

MODERN SOURCES

Abbreviations

AA	Archaeologia Aeliana
AE	L'Anée Épigraphique in Revué Archéologique
AMC	Ancient Monuments Committee
Anon	Anonymous
Ant J	Antiquaries Journal
Arch Journ	Archaeological Journal
Arch	Archaeology
BAR:BS	British Archaeological Reports British Series
BAR:IS	British Archaeological Reports International Series
Bonner Jahrb	Bonner Jahrbuch
Brit	Britannia
CAH	Cambridge Ancient History
CBA	Council for British Archaeology
CEH	Cambridge Economic History
CIL	Corpus Inscriptionum Latinarum
EHR	Economic Historical Review
EHA	English Heritage Archaeological report
HBNC	History of the Berwickshire Naturalists Club
HMSO	Her Majesty's Stationery Office
IJNAUE	International Journal of Nautical Archaeology and Underwater Exploration
JHC	Journal of the House of Commons
JRA	Journal of Roman Archaeology
JRS	Journal of Roman Studies
MAFF	Ministry of Fisheries and Food
NEECR	North England Excavation Committee Reports
PPS	Proceedings of the Prehistoric Society
PSAN	Proceedings of the Society of Antiquaries of Newcastle upon Tyne
PSAS	Proceedings of the Society of Antiquaries of Scotland
RCAMS	Royal Commission for Ancient Monuments of Scotland
RCHME	Royal Commission for Historical Monuments of England
RIB	Roman Inscriptions of Britain
SAF	Scottish Archaeological Forum
TAASDN	Transactions of the Architectural and Archaeological Society of Durham and Newcastle upon Tyne
TCWAAS	Transactions of the Cumberland and Westmoreland Antiquarian and Archaeological Society
TLMAS	Transactions of the London and Middlesex Archaeological Society
YAJ	Yorkshire Archaeological Journal

Allen, G H
1933 "A Problem in Inland Navigation in Roman Gaul", The Classical Weekly 27, pp 65-69.

Allen, J R L and Fulford, M G
1986 "The Wentlooge Level: a Romano-British saltmarsh reclamation in South-east Wales", Brit 17, pp 91-117.

Anderson, J D
1987 Aqueducts Along Hadrian's Wall, unpublished MA dissertation, University of Newcastle upon Tyne.

Anderson, J D, Rushworth, A, and Willis, R C
forthcoming "Geo-physical examinations of three sites in Northumberland".

Anderson, A C and Anderson, A S (eds.)
1981 Roman Pottery Research in Britain and North-west Europe, Oxford: BAR:BS 123, in one volume.

Andrianov, B V (ed)
1980 Navka, Moscow.[1]

Anonymous
1: 1714 1: Seasonable Considerations on a Navigable Canal intended to be cut from the River Trent, at Wilden Ferry, in the County of Derby, to the River Mersey, in the County of Chester, ms, Bodleian Library, Oxford.

2: 1713-15 2: A Bill to make the River Kennet Navigable, (Bromley's Parliamentary Papers Vol.4: MM31 JUR 3rd Series), pp 1-7, Bodleian Library.

3: 1671 Act 22 and 23, Charters II.c.25, Parliamentary Papers, Bodleian Library.

---

[1] Whenever possible, references will include the publisher's name. However, in some instances such as this, where an off-print from Andrianov, 1980 has not mentioned the publisher of Navka, the publisher's name is not included. In the case of books published through subscription, following the convention of many antiquarian scholars, printers, rather than publishers, will be acknowledged.

Applebaum, S
1972 "Roman Britain", in Finberg, 1972, pp 3-268.

1975 "Observations on the economy of the villa at Bignor, Sussex", Brit 6, pp 118-132.

Armstrong, A
1769 A map of the County of Northumberland with that part of the County of Durham that is north of the River Tyne: one inch to a mile, Newcastle upon Tyne: T Kitchin.

Arnold, B
1974 "The Gallo-Roman boat from the Bay of Bevaix, Lake Neuchâtel, Switzerland", IJNAUE 4, pp 123-6.

Arthur, P and Marsh, G (eds.)
1978 Early Fine Wares in Roman Britain, Oxford: BAR:BS 57.

Aubin, H
1925 "Der Rheinland in roemischer Zeit", Bonner Jahrb 134, pp 130-137.

Austen, P S and Breeze, D J
1979 "A New Inscription from Chesters on Hadrian's Wall", AA 5.7, pp 115-26.

Baatz, D
1977 "Review of Breeze and Dobson, 1976", Bonner Jahrb 177, pp 773-775.

Bailey, J and Culley, G
1805 General View of the Agriculture of the County of Northumberland, with Observations on the Means of its Improvement, London: MacMillan.

Baker, I A
1909 A Treatise on Masonry Construction, London, tenth edition.

Baldwin, M
1984 Canals: a new look - studies in honour of Charles Hadfield, Chichester: Phillimore.

Barber, K
1981 Peat stratigraphy and climatic change, Rotterdam: Balkema.

Barrett, J C, Fitzpatrick, A P, and Macinnes, L (eds)
1989 Barbarians and Romans in North-west Europe: from the later Republic to late Antiquity, Oxford: BAR:IS 471.

Basch, L
1972 "Ancient Wrecks and the Archaeology of Ships", IJNAUE 1, pp 1-58.

Bass, G (ed.)
1972 A History of Seafaring Based on Underwater Exploration, London: Thames and Hudson.

Bates, C J
1898 "The Beornicas and the Deras", AA 2.19, pp 147-54.

Bates, R L and Jackson, J A (eds)
1980 Glossary of Geology, Falls Church, Virginia: American Geological Institute.

Bateson, E
1895 A History of Northumberland, Newcastle upon Tyne: Andrew Reid and Company, in two volumes.

Behre, K E (ed)
1986 Anthropogenic Indicators in Pollen Diagrams, Rotterdam: Balkema.

Bell, M
1981 "Valley sediments and environmental change", in Jones and Dimbleby, 1981, pp 75-97.

Bennett, J
1980 "'Temporary Camps' along Hadrian's Wall", in Hanson and Keppie, 1980, pp 151-172.

1981 "Parton, Moresby, Cumbria", Brit 12, pp 325.

1983 "The End of Roman Settlement in Northern England ", in Chapman and Mytum, 1983, pp 186-204.

1984 "The North-east in the Second Century", in Wilson, Jones, and Evans, 1984, pp 35-38.

1990 The Setting, Development and Function of the Hadrianic Frontier in Britain, unpublished PhD thesis, University of Newcastle upon Tyne.

Bennett, J and Turner, R
1983 "The Vallum at Wallhouses, Northumberland: excavations in 1980 and 1981", AA 5.11, pp 61-78.

Binnie, G M
1987 Early Dam Builders in Britain, London: Thomas Telford.

Bidwell, P T
1985 The Roman fort at Vindolanda, London: English Heritage.

1989a "The Stone Forts", in Daniels, 1989, pp 46-9.

1989b "South Shields", in Daniels, 1989, pp 83-89.

Bidwell, P T and Holbrook, N
1989 Hadrian's Wall Bridges, London: Batsford.

Bidwell, P T and Speak, S
forthcoming The Roman fort at South Shields: the excavations of the Headquarters Building and the South West Gate.

Binnie, G M
1987 Early Dam Building in Britain, London: Telford.

Bintliff, J L and Davidson, D A and Grant, E G (eds)
1984 Conceptual Issues in Environmental Archaeology, Edinburgh: Edinburgh University Press.

Bird, J
1977 "African Red Slip Ware in Roman Britain", in Dore and Greene, 1977, pp 269-77.

Birks, H and West, R (eds)
1973 Quaternary Plant Ecology, 14th Symposium of the British Ecological Society at Oxford: Blackwell Scientific.

Birley, A R
1981 "The economic effects of Roman frontier policy", in King and Henig, 1981, pp 39-53.

Birley, E B
1949 The Centenary Pilgrimage, Kendal: The Society of Antiquaries of Newcastle upon Tyne, and the Cumberland and Westmoreland Antiquaries and Archaeological Society.

1953 Roman Britain and the Roman Army, Kendal: Titus Wilson.

1954 "The Roman fort at Netherby", TCWAAS 54, pp 6-39.

1961 Research on Hadrian's Wall, Kendal: Titus Wilson.

1966 "Review of R G Collingwood and R P Wright, The Roman Inscriptions of Britain 1: Inscription on Stone", JRS 56, pp 226-31.

Birley, R E
1977 Vindolanda: A Roman Frontier Post on Hadrian's Wall, London: English Heritage.

1989 "The Early Timber Forts", in Daniels, 1989, p 46.

Bishop, M C
1991 Recent Excavations on the Roman Fort at Chester-le-Street, Newcastle upon Tyne: The Archaeological Practice.

Bishop, M C and Dore, J N
1988 Corbridge: Excavations of the Roman Fort and Town: 1947-80, London: Historic Buildings and Monuments Commission for England.

Blagg, T F C and King, A C (eds)
1984 Military and Civilian in Roman Britain, Oxford: BAR:BS 136.

Blake, J B
1965 "Medieval smuggling in the North-east: Some fourteenth century evidence", AA 4.43, pp 243-260.

Blazquez, J M and Remesal, J (eds)
1983 Produccion y Comercio Del Aceite En La Antiguedad: Segundo Congreso Internacional, Sevilla, Madrid: Universidad Complutense.

Boddington, A
1987 The Bywell Project, Durham: CBA 3: Research Report No. 37.

Bogaers, J E
1971a "Some notes in connection with the Dutch section of the limes of Germania Inferior", in Gichon and Applebaum, 1971.

1971b "Nehallennia en de epigrafische gegevens", in Deae Nehallenniae Gids bij de tentoonstelling Nehalennia de Zeeuwse godin, Zeeland in de Romeinse tijd, Romeinse monumenten uit de Oostershelde, Middlesburg: Middlesburg Museum.

Bonnard, L
1913 La Navigation interieure dans la Gaule Romaine, Paris.

Boon, G C
1974 "Counterfeit coins in Roman Britain", in Casey and Reece, 1974, pp 95-172.

1975 "Segontium fifty years on: 1", Archaeologica Cambrensis 124, pp 52-7.

1980 "Caerleon and the Gwent Levels in Early Historic Times", in Thompson, F H, 1980, pp 24-36.

Borland, M
1971 "Chapter 29", in Shen, 1971, pp 26-35.

Bosanquet, R C and Meek, A
1902 "Excavations on the line of the Roman Wall in Northumberland", AA 2.25, pp 193-305.

Bourne, D
1967 "The Roman bridge at Corstopitum", AA 4.45, pp 17-26.

Bowden, M, Mackay, D, and Topping, P (eds)
1989 From Cornwall to Caithness: Some Aspects of British Field Archaeology, Oxford: BAR:BS 209.

Bowen, H C
1975-6 "A Romano-British site of Brownsea Island", National Trust Yearbook, pp 42-3.

Bowen, H C and Fowler, P J (eds)
1978 Early Land Allotment in the British Isles: A survey of recent work, Oxford: BAR:BS 48.

Bowman, A K
1984 The Roman Writing Tablets from Vindolanda, London: British Museum.

Bowman, A K and Thomas, J D
1983 Vindolanda: The Latin Writing-Tablets, London: Britannia Monograph Series 4.

1987 "New Texts from Vindolanda", Brit 18, pp 125-142.

Bowman, A K, Thomas, J D, and Adams, J N
1990 "Two Letters from Vindolanda", Brit 21, pp 33-52.

Boyes, J And Russell, R
1972 The Canals of Eastern England, Kendal: Titus Wilson.

Brand, J
1789 The history and antiquities of the town and county and of the town of Newcastle upon Tyne, London: B White and Son, in two volumes.

Branigan, K
1984 "North East England in the First Century", in Wilson, Jones and Evans, 1984, pp 27-33.

Branigan, K (ed)
1980 Rome and the Brigantes: the Impact of Rome on Northern England, Sheffield: University of Sheffield.

Breeze, D J
1977 "The fort at Bearsden and the supply of pottery to the Roman army", in Dore and Greene, 1977, pp 133-146.

1984 "Demand and supply on the northern frontier", in Miket and Burgess, 1984, 264-86.

1990 "The Impact of the Roman Army on the Native Peoples of North Britain", in Vetters and Kandler, 1990, pp 85-97.

Breeze, D J, and Dobson, B
1976 Hadrian's Wall, London: Allen Lane.

Brown, A G
1983 "Floodplain deposits and accelerated sedimentation in the lower Severn basin", in Gregory, 1983, pp 375-398.

Brown, C D
1944 "Discussion of Sediment in Reservoirs by B J Witzig", Transactions of the American Society of Civil Engineers 109, pp 1080-1086.

Bruce, J C
1847 Handbook to the Roman Wall, Newcastle upon Tyne: Society of Antiquaries of Newcastle upon Tyne, first edition.

1851 The Roman Wall, Newcastle upon Tyne, first edition.

1856 "Roman Chester-le-Street", PSAN 1, pp 121-21.

1857 "Account of the Excavations at the Roman Station of Bremenium, 1855", AA 2.1, pp 69-85.

1885 "Three Bridges over the Tyne", AA 2.10, pp 1-11.

Brune, G H
1953 "Troy Efficiency Reservoirs", American Geo-physical Union Transactions 34, pp 101-109.

Brunt, P A (ed)
1974 The Roman Economy: Studies in Ancient Economic and Administrative History, Oxford: Basil Blackwell.

Bulmer, W
1969 "The provisioning of Roman forts: a reappraisal of ration storage", AA 4.7, pp 7-14.

Burford, A
1960 "Heavy Transport in Classical Antiquity", EHR 2.13, pp 1-18.

Burnham, B C and Johnson, H B (eds)
1979 Invasion and Response: the case of Roman Britain, Oxford: BAR:BS 73.

Burnham, B C and Wacher, J
1990 The Small Towns of Roman Britain, London: Batsford.

Burrin, P J and Scaife, R G
1984 "Environmental Thresholds, Catastrophe Theory and Landscape Sensitivity: Their Relevance to the Impact of Man on Valley Alluviations, in Conceptual Issues", in Bintliff, Davidson, Grant, 1984, pp 211-232.

Bury, J B
1889 History of the Later Roman Empire, London and New York: 1897.

Butler, R M (ed)
1971 Soldier and Civilian in Roman Yorkshire, Leicester: Leicester University Press.

Butzer, K W
1982 Archaeology as Human Ecology, Cambridge: Cambridge University Press.

Callender, H M
1949 "Amphora stamps from Corbridge", AA 4.26, pp 60-121.

1965 Roman Amphorae London: Oxford University Press.

Camden, J
1637 Britannia, translated by P Holland, London, in three volumes.

Case, H J, and Whittle, A W R (eds)
1982 Settlement Patterns in the Oxford Region, London: CBA Research Report 44.

Casey, P J
1988 "The coins", in Bishop and Dore, 1988, pp 142-148.

Casey, P J (ed)
1979 The end of Roman Britain, Oxford: BAR:BS 71.

Casey, P J and Reece, R (eds)
1974 Coins and the Archaeologist, Oxford: BAR:BS 4.

Casey, P J and Savage, M
1980 "The coins from the excavations at High Rochester in 1852 and 1855", AA 5.8, pp 75-87.

Casson, L
1965 "Harbour and River Boats of Ancient Rome", JRS 4, pp 32.

1971 Ships and Seamanship in the Ancient World, Princeton: Princeton University Press.

1974 Travel in the Ancient World, London: Allen and Unwin.

Chapman, H
1982 "Roman vehicle construction in the north-west provinces", in McGrail, 1982, pp 187-194.

Chapman, J C and Mytum, H C (eds)
1983 Settlement in North Britain 1000 BC - 1000 AD, Oxford: Bar 118.

Chapman, W
1795a Report on the Measures to be Attended to in the Survey of a Line of Navigation from Newcastle upon Tyne to the Irish Channel, Newcastle upon Tyne: J Whitfield.

1795b Third and Last Part of a Report on the Proposed Navigation Between the east and west seas, Newcastle upon Tyne: J Whitfield.

1795c Observations on Mr John Sutcliffe's Report on a Proposed Line of Canal, from Stella to Hexham, with an Appendix containing Remarks on his Second Report., Newcastle upon Tyne: J Whitfield.

Charlesworth, D
1971 "The defences of Isurium Brigantum", in Butler, 1971, pp 155-64.

Charlesworth, M P
1926 Trade Routes and Commerce of the Roman Empire, Cambridge: Cambridge University Press, second edition.

Charlton, B and Day, J C
1985 "The Archaeological Field-Sketches of Henry MacLauchlan, Draftsman and Surveyor (1792-1882)", AA 5.13, pp 147-161.

Chevalier, R
1976 Roman Roads, London: Batsford.

Christensen, A E
1977 "Ancient Boatbuilding - a provincial classification", in McGrail, 1977.

Churchill, D M
1970 "Post-Neolithic to Romano-British Sedimentation in the southern Fenlands of Cambridge and Norfolk", in Phillips, 1970, pp 132-46.

Churchill, M A
1948 "Discussion of Analysis and Use of Reservoir Sedimentation Data by L C Gottschalk", Proceedings of the Federal Interagency Sedimentation Conference, Denver, Colorado 1947, pp 139-40.

Clack, P A G
1982 "The Northern Frontier: Farmer in the military zone", in Miles, 1982, pp 377-402.

Clack, P A G and Gill, B H
1981 "The Land Divisions of County Durham in the Early Medieval Period", 28th Report of the medieval Village Research Group for 1980 Durham University.

Clack, P A G and Haselgrove, D (eds)
1981 Rural Settlement in the North, Durham: CBA 3, Research Report No. 31.

Clark, J G D
1949 "Report on the Excavation of the Cambridgeshire Car Dyke", Ant J 29, pp 145-63.

1952 Prehistoric Europe: the Economic Basis, London: Methuen and Company.

Clark, R L
1982 "Point count estimation of charcoal in pollen preparation and thin sections of sediments", Pollen et Spores 24, pp 523-5.

Clarke, H
1979 "The Archaeology, History and Architecture of Medieval Ports of the East Coast of England with special reference to King's Lynn, England", in McGrail, 1979, pp 155-165.

Cleere, H
1978 "Roman harbours in Britain south of Hadrian's Wall", in Taylor and Cleere, 1978, pp 36-40.

Cleere, H and Crossley, P
1985 The Iron Industry of the Weald, Leicester.

Collingwood, R G
1921 "The Purpose of the Roman Wall", Vasculum 8, pp 4-9.

1930 "Romano Celtic Art in Northumbria", Arch 80, pp 37-58.

1933 "Prehistoric Settlements near Crosby, Ravensworth", TCWAAS 33, pp 201-206.

Collingwood, R G and Wright, R P
1965 Roman Inscriptions of Britain, Oxford: Clarendon Press.

Cooter, W S
1977 "Preindustrial Frontier and Interaction Spheres: prolegomenon to a study of Roman frontier regions", in Miller and Steffen, 1977, pp 81-107.

Cornell, T and Matthews, J
1982 Atlas of the Roman World, Oxford: Clarendon Press.

Coupland, F
1987 The Piercebridge Formula: an Appraisal, Sheffield University: Unpublished BA Dissertation.

Courteault, P
1921 "An inscription recently found at Bordeaux", JRS 11, pp 101-7.

Cowley, D C and Edwards, D
1988 Callaly Moor field survey and excavation: phase three, Newcastle upon Tyne: Archaeological Unit for North-east England.

Crow, J
1989 Housesteads Roman Fort: Northumberland, London: English Heritage.

Crummy, P (ed)
1972 Excavations at Lion Walk, Balkerne Lane, and Middleborough, Colchester, Essex, Colchester: Colchester Archaeological Report 3.

Cummins, G
1991 Palaeoecological Reconstruction of Binchester Roman fort, unpublished BA dissertation, University of Newcastle upon Tyne.

Cunliffe, B
1966 "The Somerset Levels in the Roman period", in Thomas, 1966, pp 68-73.

1974 Iron Age Communities in Britain, London: Routledge and Kegan Paul.

1979 The Celtic World, London: Bodley Head.

1983 Danebury: The Anatomy of an Iron Age Hill Fort, London: Batsford Academic.

Cunliffe, B (ed)
1988 The Temple of Sulis Minerva at Bath: Volume Two - The Finds from the Sacred Spring, Oxford: Oxford University Committee for Archaeology.

Cuntz, O
1929 Itineraria Romana Volumen Prius Itineraria Antonini Augusti Et Burdigalense, Leipzig.

Curle, J
1911 A Roman Frontier Post and its People: The Fort of Newstead, Glasgow: J Maclehose and Sons.

Curle, J and Cree, J
1915; 1920-24 "Account of the Excavations on Traprain Law", PSAS 50, 54-8.

Curnow, P and Reece, R
1969 "Verulamium 1966-8. A note on the histograms", Antiquity 45, pp 51-2.

Daniels, C M
1959 "The Roman Bath House at Red House, Corbridge", AA 4.37, pp 85-176.

1968 "A Hoard of Iron and Other Materials from Corbridge", AA 4.46, pp 115.

1970 "Problems of the Northern Roman Frontier", SAF 2, pp 91-101.

1976 "Wallsend Fort", Brit 7, pp 306-8.

1980 "A New Inscription of Julia Domna from Newcastle", AA 5.8, pp 65-73.

1991 "The Antonine Abandonment of Scotland", in Maxfield and Dobson, 1991, pp 48-51.

Daniels, C M (ed)
1978 Handbook to the Roman Wall, Newcastle upon Tyne: PSAN, thirteenth edition.

1989 "The Eleventh Pilgrimage of Hadrian's Wall", Newcastle upon Tyne: Society of Antiquaries of Newcastle upon Tyne, and Cumberland and Westmoreland Antiquarian and Archaeological Society.

Darling, M J and Jones, M J
1988 "Early Settlement at Lincoln", Brit 19, pp 1-57.

Davies, G and Turner, J
1979 "Pollen Diagrams from Northumberland", New Phytologist 82, pp 783-804.

Davies, R W
1967 "A Note on a recently discovered Inscription from Carrawburgh", Epigraphische Studien 4, pp 108-111.

1968 "A note on some Roman soldiers in quarries", TCWAAS 68, pp 23-26.

1970a "The Roman military medical service", Saalburg Jahrbuch 27, pp 84-104.

1970b "Some Roman Medicine", Medical History 14, pp 101-6.

1971 "The Roman Military Diet", Brit 2, pp 122-130.

1974 "The daily life of the Roman soldier under the Principate", in H Temporini, 1974, pp 299-338.

de Boe, G
1978 "Roman boats from a small river harbour at Pommeroeul, Belgium", in Taylor and Cleere, 1978, pp 22-30.

Defoe, D
1724 A Tour Through the Whole Island of Great Britain, reprinted in 1974, London: Dent.

Delibrias, G and Guillier M T
1971 "The Sea-Level on the Atlantic Coast and the Channel for the last 10,000 years, by the C14 method", Quaternaria 15, pp 131-5.

Dent, J
1983 "The Impact of Roman Rule on native Society in the Territory of the Parisi", Brit 14, pp 33-44.

De Salis, H R
1904 Bradshaw's Canals and Navigable Rivers of England and Wales, London and Manchester: Henry Blacklock and Company.

Detsicas, A (ed)
1973 Current Research in Romano-British Coarse Pottery, London: CBA Research Report 10.

de Weerd, M D
1978 "Ships of the Roman Period at Zwammerdam/Nigrum Pallum, Germania Inferior", in Taylor and Cleere, 1978, pp 15-21.

Dickinson, B M and Hartley, K F
1971 "The evidence of potters' stamps on samian ware and mortaria for the trading connections of Roman York", in Butler, 1971, pp 127-142.

Dix, B and Taylor, S
1988 "Excavations at Bennaventa, 1970-1", Brit 19, pp 299-339.

Dobson, B
1986 "The Function of Hadrian's Wall", AA 5.14, pp 1-30.

Dodd, R
1795 Report on the First Part of the Line of Navigation from the East to the West Sea by way of Newcastle and Carlisle, as originally projected, and later surveyed, Newcastle upon Tyne: J Whitfield.

Doppelfeld, O
1966 Römisches und fränkisches Glas in Köln, Köln: Köln Zentralmuseums.

Dore, J N
1980 "The fort at Red House and Flavian coarse pottery in Northern Britain", in Hanson and Keppie, 1980, pp 113-118.

Dore, J N and Gillam, J P
1979 The Roman fort at South Shields, Newcastle upon Tyne: Society of Antiquaries of Newcastle upon Tyne.

Dore, J N and Greene, K (eds)
1977 Roman Pottery Studies in Britain and Beyond, Oxford: BAR:IS 30.

Dornier, A
1966 "Knag Burn, Housesteads, Northumberland: an interim report", ms, Department of Archaeology Library, University of Newcastle upon Tyne.

Drachmann, A G
1963 The Mechanical Technology of Greek and Roman Antiquity, London: Hafner.

Duckham, B J
1967 The Yorkshire Ouse, Newton Abbot: David and Charles.

Duncan-Jones, R
1974 The Economy of the Roman Empire: quantitative studies, Cambridge: Cambridge University Press.

Dymond, D P
1963 "Roman Bridges on Dere Street, County Durham", Arch Journ 118, pp 136-164.

Dyson, S L
1985 The Creation of the Roman Frontier, Princeton: Princeton University Press.

Eckholdt, M
1984 "Navigation on small rivers in Central Europe in Roman and Medieval times", IJNAUE 17, pp 3-10.

Ellmers, D
1969 "Keltischer Schiffbau", Jahr des Römisch-Germanischen Zentralmuseums 16, pp 116-19.

1973 "Rheinshciffe der Römerzeit", Beiträge zur Rheinkunde 25, pp 40-51.

1978 "Shipping on the Rhine during the Roman Period: the pictorial evidence", in Taylor and Cleere, 1978, pp 1-14.

1974 "Vorund frühgeschichtliche Schiffahrt am Nordrand der Alpen", Helvetia Archaeologica 19-20, pp 94-104.

Engels, D W
1978 Alexander the Great and the Logistics of the Macedonian Army, Berkeley: Berkeley University Press.

Erim, K T and Reynolds, J
1973 "The Aphrodisias copy of Diocletian's Edict on Maximum prices", JRS 63, pp 99-110.

Evans, K J
1965 "Dug-out canoes found in the river Arun", Sussex Notes and Queries 16, pp 185-7.

Evans, J
1984 "Settlement and Society in North-east England in the fourth century", in Wilson, Jones and Evans, 1984, pp 43-48.

Evans, J and Cleere, H and Limbrey, S (eds)
1975 The effect of man on the Landscape: the Highland Zone, Oxford: CBA Research Report 11.

Farrar, R A H
1973 "The Techniques and Sources of Romano-British black-burnished Ware", in Detsicas, 1973, pp 67-103.

Fawcett, W C
1966 "Lanchester Road Section", Archaeological News 44, pp 3-5.

Feacham, R W
1977 Guide to Prehistoric Scotland, London: Batsford.

Ferguson, R I
1981 "Channel forms and channel changes", in Lewin, 1981, pp 90-121.

Finberg, H (ed)
1972 Agrarian History I, Cambridge: Cambridge University Press.

Fink, R O
1958 "Hunt's Pridianum: British Museum Papyrus 2851", JRS 48, pp 102-116.

Finley, M I
1973 The Ancient Economy, London: Chatto and Windus.

Forster, R H and Knowles, W H
1910 "Corstopitum: Report on the Excavations in 1909", AA 3.6, pp 205-273.

1911 "Corstopitum: Report on the Excavations in 1910", AA 3.7, pp 130-142.

1914 "Corstopitum: Report on the Excavations in 1913", AA 3.11, pp 279-307.

Fowler, G
1934 "The Extinct Waterways of the Fens", Geographical Journal 83, pp 30-9.

Fowler, P J
1983 The Farming of Prehistoric Britain, Cambridge: Cambridge University Press.

Fox, C
1932 The Personality of Britain, Cardiff: National Museum of Wales.

Fraser, C M
1961 "Medieval Trading Restrictions in the North-east", AA 4.39, pp 135-151.

Frere, S S
1974, 1978 and 1987 Britannia, London: Routledge and Kegan Paul, first, second, and third editions.

Frere, S S (ed)
1988 "Roman Britain in 1987 I: Sites Explored", Brit 19, pp 416-484.

Frere, S S and Tomlin, R S O (eds)
1991 Roman Inscriptions of Britain II, Fasc.2, Bath: Alan Sutton.

Frere, S S and Wilkes, J J (eds)
1989 Strageath, London: Society of Antiquaries of London, British Monograph Series, 9.

Fulford, M
1977a "The location of Romano-British pottery kilns: institutional trade and the market", in Dore and Greene, 1977, pp 301-316.

1977b "Pottery and Britain's Foreign Trade in the Later Roman Period", in Peacock, 1977, pp 35-84.

1978 "The interpretation of Britain's late Roman trade: the scope of medieval historical and archaeological analogy", in Taylor and Cleere, 1978, pp 59-69.

1984 "Demonstrating Britannia's economic dependence in the first and second centuries", in Blagg and King, 1984, pp 129-142.

1989 "The Economy of Roman Britain", in Todd, 1989, pp 175-201.

Fulford, M and Bird, J
1975 "Imported Pottery from Germany in Late Roman Britain", Brit 6, pp 171-81.

Funari, P P A
1991 "Dressel 20 amphorae inscriptions found at Vindolanda: the reading of the unpublished evidence", in Maxfield and Dobson, 1991, pp 65-72.

Gardiner, V (ed)
1987 International Geomorphology 1986, London: John Wiley and Sons.

Garnsey, P
1983 "Grain for Rome", in Garnsey et al, 1983, pp 118-130.

Garnsey, P and Hopkins, K and Whittaker, C R (eds)
1983 Trade in the Ancient Economy, London: Chatto and Windus.

Gates, T
1981 "Farming on the frontier: Romano-British fields in Northumberland", in Clack and Haselgrove, 1981.

1982 "Field Survey and Assessment in Northumberland", in Rural Excavation and Survey Project, Newcastle upon Tyne: Archaeological unit for the North-east of England, Typescript Report.

1983 "Unenclosed settlements in Northumberland", in Chapman and Mytum, 1983, pp 103-148.

Gentry, A
1976 Roman Military Stone-Built Granaries in Britain, Oxford: BAR:BS 32.

Giardina, A
1981 "Allevamento ed economia della selva. Italia meidionale: transformazioni e continuita", in Giardina and Schiavaone, 1981, pp 87-113.

Giardina, A and Schiavaone (eds)
1981 Societa roman e produzione schiavistica I: l'Italia: insediamenti e forma economiche, Rome: Laterza.

Gichon, M and Applebaum, S (eds)
1967 Roman Frontier Studies: papers presented to the 7th International Congress, Tel Aviv, London.

Gilbert, E
1946 "New Views on Warden, Bywell, and Heddon-on-the-Wall churches", AA 4.24, pp 157-182.

Gillam, J P
1970 Types of Roman Coarse Pottery Vessels in Northern Britain, Newcastle upon Tyne: Oriel Press, third edition.

1973 "Sources of pottery found on northern military sites", in Detsicas, 1973, pp 53-62.

1977 "The Roman forts at Corbridge", AA 5.5, pp 47-74.

Gillam, J and Greene, K
1981 "Roman Pottery and the Economy", in Anderson and Anderson, 1981, pp 1-16.

Gillam, J P, Harrison, R M, and Newman, T G
1973 "Interim Report on Excavations at the Roman Fort at Rudchester", AA 5.1, pp 81-85.

Gillam, J and Tait, J
1968 "The Roman fort at Chester-le-Street", AA 4.46, pp 75-96.

Godwin, H
1968 "Organic Deposits at Old Buchenham Mere, Norfolk", New Phytologist 67, pp 95-197.

Goodburn, R
1976 "Roman Britain in 1975 I: Sites Explored", Brit 7, pp 290-377.

Gordon, A
1726 Itinerarium Septentrionale, London.

Graf, W L
1985 The Colorado River: Instability and Basin Management, Washington: Association of American Geographers.

Green, L G
1973 When the Journey's Over: An incorrigible old wanderer's memories of travel in the Cape and far beyond the Cape, London: Hale.

Greene, K
1973 "The pottery from Usk", in Detsicas, 1973, pp 25-37.

1977 Discovering the Roman North, Durham: University of Durham.

1978a "Imported fine wares in Britain to AD 250: A guide to identification", in Arthur and Marsh, 1978, pp 15-30.

1978b "Roman trade between Britain and the Rhine provinces: the evidence of pottery to c AD 250", in Taylor and Cleere, 1978, pp 52-58.

1979 "Invasion and Response: Pottery and the Roman Army", in Burnham and Johnson, 1979, pp 99-108.

1986 Archaeology of the Roman Economy, London: Batsford.

Greenhill, B
1969 "The Archaeology of the Boat, a new introductory study", Industrial Archaeology 6, pp 212-214.

Gregory, K J (ed)
1983 Background to Palaeohydrology: A Perspective, Chichester: Wiley and Sons.

Grenfell, B P and Hunt, A S
1903-5 Catalogue hoard des Antiquitées Egyptiennes du Musée du Caire, Oxford.

Groenmann-van Waateringe, W
1980 "Urbanization and the North-west Frontier of the Roman Empire", in Hanson and Keppie, 1980, pp 1037-1044.

1989 "Food for Soldiers, Food for Thought", in Barrett et al, 1989, pp 96-107.

Hadfield, C
1966 The Canals of the West Midlands, 1966, U.K.: Phillimore.

Hadfield, C and Biddle, G
1970 The Canals of North West England, Newton Abbot: David and Charles, in two volumes.

Hafemann, Dr
1956 "Geographie des römischen Britannien", Beiträge Zur Ziedlungsgeschichte 1, pp 146-152.

Haigh, D and Savage, M
1984 "Sewingshields", AA 5.12, pp 33-147.

Hallam S J
1970 "Settlement round the Wash", in Phillips, 1970, pp 22-113.

Halliday, S P
1986 "Cord Rig and Early Cultivation in the Borders", PSAS 116, pp 584-5.

Hammond, N G L and Scullard, H H
1970 Oxford Classical Dictionary, Oxford: Clarendon Press, second edition.

Hanson, J C
1970 Municipal and Military Water Supply and Drainage in Roman Britain, University of London: Unpublished PhD thesis.

Hanson, W S
1977 "Croy Hill", DEAS pp 12-13.

1982 "Roman military timber buildings: construction and reconstruction", in McGrail, 1982, pp 169-186.

Hanson, W S and Daniels, C M and Dore, J V and Gillam, J P
1979 "The Agricolan Supply Base at Red House, Corbridge", AA 5.7, pp 1-88.

Hanson, W S and Keppie, L J F (eds)
1980 Roman Frontier Studies 1979: papers presented to the 12th International Congress, University of Stirling, Oxford: BAR:IS 71, in three volumes.

Harbottle, B, Fraser, R and Burton, F C
1988 "The Westgate Road Milecastle, Newcastle upon Tyne", Brit 19, pp 153-162.

Harding, D W
1970 "Holme House", Brit 1, pp 279-80.

Harding, D W (ed)
1976 Hillforts: Later Prehistoric Earthworks in Britain and Ireland, London.

Harris, D R
1966 "Recent Plant Invasions in the Arid and Semi-arid Southwest of the United States", Annals: Association of American Geographers 56, pp 408-22.

Hartley, B R
1972 "The Roman occupation of Scotland: the evidence of samian ware", Brit 3, pp 1-55.

Hartley, B R and Kaine, K F
1954 "Heronbridge excavations: Roman dock and buildings", Journal of Chester Arch Soc 41, pp 1-14.

Hartley, K F
1973 "The marketing and distribution of mortaria", in Detsicas, 1973, pp 39-51.

Harvey, A M and Renwick, W H
1987 "Holocene alluvial fan and terrace formation in the Bowland Fells, Northwest England", Earth Surf Proc Land 12, pp 249-257.

Haselgrove, C
1984 "The Later pre-Roman Iron Age Between the Humber and Tyne", in Wilson, Jones, and Evans, 1984, pp 9-26.

Haselgrove, C and Turnbull, P
1987 Stanwick, Excavations and Research, Interim Report 1985-6, University of Durham, Occasional paper number 8.

Hassall, M
1978 "Britain and the Rhine provinces: epigraphic evidence for Roman trade", in Taylor and Cleere, 1978, pp 41-48.

Hassall, M and Tomlin, R S O
1977 "Roman Britain in 1976 II: Inscriptions in Stone", Brit 8, pp 426-449.

Haverfield, F
1903 "Discovery of Roman inscriptions, etc. at Newcastle: An inscribed slab, mentioning the 2, 6, and 20 legions from the Tyne", AA 2.25, pp 142-145.

1916 "Modius Claytonensis: The Roman Bronze Measure from Carvoran", AA 3.13, pp 85-102.

Haverfield, F and Collingwood, R G
1920 "The Provisioning of Roman Forts", TCWAAS 2.20, pp 127-142.

Hayes, R H and Hemingway, J E and Spratt, D A
1980 "The distribution and lithology of Beehive querns in North east Yorkshire", Journal of Archaeological Science 7, pp 297-324.

Hearne, J
1964 The Itineraries of John Leland, in or about the years 1535-1543, London: Centaur Press.

Hedley, W P
1931 "Ancient Agriculture at Housesteads", Ant J 5, pp 351-4.

Helbaek, H
1964 The Isca grain, a Roman plant introduction in Britain", New Phytologist 63, pp 158-164.

Heslop, D
1983 The excavation of an Iron Age Settlement at Thorpe Thewles, Cleveland, 1980-82, Cleveland: Cleveland County Archaeology/CBA. Recent Excavations in Cleveland pp 17-20.

Higham, N J
1980 "Native Settlements West of the Pennines", in Branigan, 1980, 41-47.

1981 "The Roman impact upon rural settlement in Cumbria", in Clack and Haselgrove, 1981.

1986 The Northern Counties to AD 1000, London.

1989 "Roman and native in England north of the Tees: Acculturation and its limitations", in Barrett et al, 1989, pp 153-174.

Higham, N J and Jones, G D B
1983 "The excavation of two Romano-British farm sites in north Cumbria", Brit 14, pp 45-72.

Hill, D
1981 An Atlas of Anglo-Saxon England, Oxford: Basil Blackwell.

Hill, P R
1981 "Stonework and the Archaeologist: including a stonemason's view of Hadrian's Wall", AA 5.9, pp 1-22.

Hird, J
1977 Vindolanda V: the pre-Hadrianic pottery, Bardon Mill.

Hobley, A S
1989 "Numismatic evidence for post-Agricolan Scotland", Brit 20, pp 69-75.

Hodgson, G W I
1968 "A Comparative Account of the Animal Remains from Corstopitum and the Iron Age Site of Catcote near Hartlepool, County Durham", AA 4.46, pp 127-162.

1971 "Report on the animal remains recovered from the site of the Roman fort at South Shields, County Durham", AA 4.49, pp 135-138.

Hodgson, J
1807 Picture of Newcastle upon Tyne, Newcastle upon Tyne, first edition.

1812 Picture of Newcastle upon Tyne, Newcastle upon Tyne, second edition.

1822 "Observations on an ancient aqueduct and certain heaps of iron scoria, in the Parish of Lanchester, in the County of Durham", AA 1, pp 118-121.

1824 Notes concerning the Roman fort at Risingham, Northumberland Record Office, reference number ZAN M15/A37 153, Newcastle upon Tyne.

Hodgson, J C
1904 A History of Northumberland, Newcastle upon Tyne: Graham, volume seven.

Hodgson, N
1984 The Roman Archaeology of County Durham: a Survey of the Published Evidence, unpublished MA Dissertation, University of Newcastle upon Tyne.

Hogg, A H A
1943 "Native Settlements of Northumberland", Antiquity 17, 136-147.

1975 Hill-forts of Britain, London: Hart-Davis and MacGibbon.

Hooppell, R E
1882 "On the evidence of a Roman bridge at Hylton", Newcastle Daily Journal, July 17.

1891 Vinovia: a buried Roman City in the County of Durham, London: Whiting and Company.

Hope Dodds, M (ed)
1940 A History of Northumberland, Newcastle upon Tyne: The Northumberland County History Commission, volume fifteen.

Hope-Taylor, J
1977 Yeavering: An Anglo-British Centre of Early Northumbria, London: HMSO, Department of the Environment Archaeological Reports No. 7.

Hopkins, K
1980 "Taxes and Trade in the Roman Empire (200 BC - AD 400)", JRS 70, pp 101-125.

1983 "Introduction", in Garnsey, Hopkins and Whitaker, 1983, pp i-xxv.

Hornell, J
1946 Water Transport, Newton Abbot: David and Charles.

Horsley, J
1732 Britannia Romana, or the Roman Antiquities of Britain, London: J Osborne and T Longman.

Hunter, C
1721 "Roman Inscriptions and Antiquities in Yorkshire", The Philosophical Transactions and Collections Abridged 5.2, pp 44-82.

Hunter-Blair, P
1975 Roman Britain and Early England, London: Cardinal.

Hurst, H
1988 "Gloucester", in Webster, 1988, pp 48-73.

Hutchinson
1794 History of Durham, Newcastle upon Tyne: T Saint.

Hyland, A
1990 Equus: The Horse in the Roman World, London: Batsford Ltd.

Iley, W
1974 "The Stones of St Andrew's, Corbridge", AA 5.2, pp 201-211.

Isaac, B
1984 "Bandits in Judaea and Arabia", Harvard Studies in Classical Philology 88, pp 171-203.

1990 The Limits of Empire, Oxford: Oxford University Press.

Jackman, W T
1962 The Development of Transportation in Modern England, London: Frank Cass, second edition.

Jackson, D A and Ambrose, T M
1976 "A Roman Timber Bridge at Aldwincle, Northamptonshire", Brit 7, pp 39-72.

Jackson, D A and Tylecote, R F
1988 "New Romano-British Iron-Working Sites in Northamptonshire", Brit 19, pp 275-298.

Jarrett, M G
1976 Maryport, Cumbria: A Roman Fort and its Garrison, Kendal: Titus Wilson.

Jarrett, M G and Dobson, B
1965 Britain and Rome, Kendal: Titus Wilson.

Jervoise, E
1931 The Ancient Bridges of the North of England, Westminster: The Architectural Press.

Jessop, W and Chapman, W
1795 Report on the Proposed Line of Navigation Between Newcastle and Maryport, with Abstracts of the Estimates of this Line, and also of that From Stella to Hexham, Newcastle: J Whitfield.

Jewell, P A (ed)
1963 The Experimental Earthwork on Overton Down, Wiltshire, 1960, London: British Association for the Advancement of Science.

Jobey, G
1959 "Excavations at a Native Settlement at Huckhoe, Northumberland", AA 4.38, pp 117-178.

1960 "Some rectilinear Settlements of the Roman Period in Northumberland: Part I", AA 4.38, pp 1-38.

1963 "Additional Rectilinear Settlements in Northumberland", AA 4.41, pp 211-215.

1964 "Romano-British enclosed stone-built settlements", AA 4.42, pp 41-64.

1965 "Hill forts and settlements in Northumberland", AA 4.43, pp 21-64, map 57.

1966 "Homesteads and Settlements in the Frontier Area", in Thomas, 1966, pp 1-14.

1970 "An iron Age Settlement and Homestead at Burradon, Northumberland", AA 4.48, pp 51-95.

1973 "A native settlement at Hartburn and the Devil's Causeway, Northumberland, 1971", AA 5.1, pp 11-53.

1974 "Notes on some population problems between the two Roman walls", AA 5.2, pp 17-26.

1976 "Traprain Law: A Summary", in Harding, 1976, pp 191-204.

1982 "The settlement at Doubtstead and the Romano-British settlements on the coastal plain between Tyne and Forth", AA 5.10, pp 1-24.

Johnson, Rev A
1889 "Bywell", AA 2.13 pp 89-166.

1894 "Blanchland", AA 2.16, pp 295-312.

Johnson, R W
1895 The making of the Tyne: a record of fifty year's progress, London: W Scott Ltd.

Johnston, D E
1979 An Illustrated History of Roman Roads in Britain, Bourne End: Spurbooks.

Johnstone, P
1980 The Seacraft of Prehistory, London: Routledge and Kegan Paul.

Jones, A H M
1973 The Later Roman Empire 284-602. A Social, Economic and Administrative Survey, London: Longmans, in two volumes, first printed in 1964.

1974 "The Roman Economy: Studies in Ancient Economic and Administrative History", in Brunt, 1974.

Jones, M E
1981 "The Development of Crop Husbandry", in Jones and Dimbleby, 1981.

Jones, M E and Casey, J
1988 "The Gallic Chronicle Restored: A Chronology for the Anglo-Saxon Invasions and the End of Roman Britain", Brit 19, pp 367-398.

Jones, M E and Dimbleby, G (eds)
1981 The environment of man: the Iron Age to the Anglo-Saxon period, Oxford: BAR:BS 87.

Jones, P D
1977 A Spatially Distributed Catchment for Flood Forecasting and River Regulation with Particular Reference to the River Tyne, unpublished PhD thesis, University of Newcastle upon Tyne.

Jones, P D, Ogilvie, A E J, and Wigley, T M L
1984 Riverflow Data for the United Kingdom: Reconstructed Data Back to 1844 and Historical Data Back to 1556, Norwich: Climatic Research Unit, University of East Anglia.

Jones, R F J
1984a "Settlement and Society in North-east England in the Third Century", in Wilson, Jones, and Evans, 1984, pp 39-42.

1984b "Urbanisation in the Roman north", in Wilson et al, 1984, pp 87-88.

1990 "Natives and the Roman Army: Three Model Relationships", in Vetters and Kandler, 1990, pp 99-110.

Jope, E M
1956 "Vehicles and Harness", in Singer et al, 1956, pp 537-562.

Jull, S P, and Lees, T P
1990 Studies of Historic Concrete, Middlesex: Taywood Engineering Ltd Research Laboratories Technical Report.

Jusserand, J J
1889 English Wayfaring Life in the Middle Ages, London: T F Unwin.

Kay, G
1794 General View of the Agriculture of North Wales, Montgomeryshire, Edinburgh: Moir.

Kennedy, D L
1986 "The place-name Arbeia", Brit 17, pp 332-3.

Kenward, H D and Williams, K
1979 "Biological evidence from the Roman warehouses at Coney Street", The Past Environment at York 14.2.

Kilbride-Jones, H E
1938 "The Excavation of a Native Settlement at Milking Gap, High Shield, Northumberland", AA 4.15, pp 303-350.

King, A
1981 "The decline of samian ware manufacture in the North West Provinces: problems of chronology and interpretation", in King and Henig, 1981, pp 55-78.

King, A and Henig, M (eds)
1981 The Roman West in the Third Century: Contributions from Archaeology and History, Oxford: BAR:BS 109, in two volumes.

Kirby, D
1969 "Lumley Lock - An historical note on an ancient fishery", AA 4.47, pp 125-135.

1972 "The Wear Navigation and the City of Durham in the Eighteenth Century", AA 4.50, pp 263-275.

Kitson Clark, M
1934 "Roman Yorkshire in 1933", YAJ 31, pp 382-387.

Klige, R K
1980 "Reconstruction of the Hydrological Balance in the Caspian Sea", in Andrianov, 1980, pp 117-20.

Knighton, D
1984 Fluvial Forms and Processes, Bungay: The Chaucer Press.

Knights, B A
1983 "Evidence concerning the Roman military diet at Bearsden, Scotland in the second century AD", Journal of Archaeological Science 10.2, pp 139-52.

Kurchin, B
1983 The Effect of Colonization on the Votadini: A Settlement System Analysis, Unpublished MA Thesis: Hunter College, The City University of New York.

Lamb, H H
1977 Climate: Present, Past and Future. Volume 2 - Climatic history and the future, London: Methuen.

1981 "Climate from 1000 BC to 1000 AD", in Jones and Dimbleby, 1981, pp 53-65.

Lambrick, G and Robinson, M
1979 Iron Age and Roman riverside settlements at Farmoor, Oxfordshire, Oxford: CBA Research Report 32.

Landels, J G
1978 Engineering in the Ancient World, Berkeley: Berkeley University Press.

Lane, R H
1935 "Waggons and their Ancestors", Antiquity 9, pp 140-50.

Lefebvre des Noettes
1931 L'Attelage, le Cheval de Selle a Travers Lesages, Paris.

Leighton, A C
1972 Transport and Communication in Early Medieval Europe, Newton Abbot: David and Charles.

Lethbridge, T C
1927 "An Anglo-Saxon hut on the Car Dyke, at Waterbeach", Arch Journ 7, pp 141-6.

Lewin, J
1978 "Floodplain Geomorphology", Progress in Physical Geography 2.3, pp 408-37.

1981 "Contemporary erosion and sedimentation", in Lewin, 1981, pp 35-57.

Lewin, J (ed)
1981 British Rivers, London: George Allen and Unwin.

Lewis, M J T
1984 "Roman navigation in the North of England", Journal of the Railway and Canal Historical Society 28, pp 118-24.

Lewis, M J T and Slatcher, W N and Jarvis, P N
1969 "Flash-locks on English waterways", Industrial Archaeology 6, pp 212-214.

Lewis, P R and Jones, G D B
1969 "The Dolaucothi Gold Mines I: the surface evidence", Ant J 49, pp 244-272.

Limbrey, S and Evans, J G (eds)
1978 The Effect of Man on the Landscape: the Lowland Zone, London: CBA Research Report No. 21.

Liversidge, J E A
1968 Britain in the Roman Empire, London: Routledge and Kegan Paul.

Lloyd-Morgan, G
1977 "Two Roman Mirrors from Corbridge", AA 1.8, pp 335-6.

1980 "Roman mirrors and Pictish symbol: a note of trade and contact", in Hanson and Keppie, 1980, pp 97-106.

1981 "Roman mirrors and the third century", in King and Henig, 1981, pp 145-158.

Long, C
1984 "Excavations at Catcote, West Hartlepool, County Durham: Preliminary Report", from Haselgrove, 1984, in Wilson, Jones, and Evans, 1984, pp 9-26.

Lopez, R S and Raymond, J W
1955 Medieval Trade in the Mediterranean World: Illustrated Documents, New York: Columbia University Press.

McCarthy, M R, Padley, T G and Henig, M
1982 "Excavations and Finds from the Lanes, Carlisle", Brit 13, pp 79-89.

McCord, N, and Jobey, G
1968 "Notes on Air Reconnaissance in Northumberland and Durham", AA 4.46, pp 51-67.

1971 "Notes on Air Reconnaissance in Northumberland and Durham: II", AA 4.49, pp 119-130.

McGrail, S
1978 Logboats of England and Wales, Oxford: BAR:BS 51, in two volumes.

1980 The Seacraft of Prehistory, London: Routledge and Kegan Paul.

1984 "Towards a Classification of Water Transport", World Archaeology 16.3, pp 289-303.

McGrail, S (ed)
1977 Sources and Techniques in Boat Archaeology, Oxford: Greenwich Archaeological Series 1.

1979 Medieval Ships and Harbours in Northern Europe, Greenwich: National Maritime Museum Archaeological Series 5, BAR:IS 66.

1981 Rafts, Boats, and Ships from Prehistoric Times to the Medieval Era, London: HMSO.

1982 Woodworking Techniques before AD 1500, Oxford: BAR:BS 129.

MacKenzie, E
1825 An Historical, Topographical, and Descriptive View of the County of Northumberland, etc, Newcastle upon Tyne: MacKenzie Bookseller of Newcastle upon Tyne, in two volumes.

MacLauchlan, H
1852 Survey of Watling Street, London: Printed for Private Circulation by the Duke of Northumberland.

1864 Memoir Written during a Survey of the Eastern Branch or the Watling Street, in the County of Northumberland, From Bewclay to Berwick-upon-Tweed, Newcastle upon Tyne: Society of Antiquaries of Newcastle upon Tyne.

1867 Notes (Not Included in the Memoirs Already Published) on Roman Roads in Northumberland, London: Printed for private circulation by the Duke of Northumberland.

Macklin, M G, Passmore, D G, Cowley, D C, Stevenson, T C and O'Brien, C F
forthcoming "Geo-archaeological Enhancement of River Valley Archaeology".

Milne, A M
1955 The Economics of Inland Transport, London: Sir Isaac Pitman and Sons, Ltd.

Ministry of Fisheries and Food
1991 Final Results of the June 1990 Agricultural and Horticultural Census: England and Wales, Regions and Counties, Guildford: MAPP.

Mann, J C
1975 The Romans in the North, Lancaster and Durham: The Universities of Lancaster and Durham.

1979 "Hadrian's Wall: the last phases", in Casey, 1979, pp 144-51.

1990 "The Function of Hadrian's Wall", AA 5.18, pp 51-54.

Mann, J C and Breeze, D
1987 "Ptolemy, Tacitus and the Tribes of North Britain", PSAS 117, pp 83-91.

Mann, J C and Penman, R G
1977 Literary sources for Roman Britain, London: London Association of Classical Teachers.

Manning, W H
1975 "Economic influences on land use in the military areas of the Highland zone during the Roman period", in Evans, Cleere and Limbrey, 1975, pp 112-116.

1976 Catalogue of Romano-British Ironwork, Newcastle upon Tyne: Newcastle University.

1979 "The native and Roman contribution to the development of metal industries in Britain", in Burnham and Johnson, 1979, pp 111-122.

Margary, I D
1948 Roman Ways in the Weald, London: Phoenix House.

1973 Roman Roads in Britain, London: John Baker, second edition.

Mariette, H
1971 "L'Archéologie des Depots Flandriens du Boulonnais", Quaternaria 14, pp 137-50.

Marsden, P
1965 "A boat of the Roman Period discovered on the site of New Guy's House, Bermondsey, 1958", TLMAS 21, pp 118-31.

1967 A Roman ship from Blackfriars, London, London: Guildhall Publications.

1972 "Ships of the Roman Period and after in Britain", in Bass, 1972, pp 113-132.

1974 "The County Hall Ship", IJNAUE 3, pp 55 -65.

Mason, D J P
1977 "The Extramural Area", in Strickland and Davey, 1977, pp 29-40.

1988a "Prata Legionis in Britain", Brit 19, pp 163-189.

1988b "The Roman Site at Heronbridge, near Chester, Cheshire: Aspects of Civilian Settlement in the Vicinity of Legionary Fortresses in Britain and Beyond", Arch Journ 145, pp 123-157.

Matherat, G
1937 "La Technique des Ponts-des-Fascines de César", Revué Archéologique 9, pp 38-62.

Mattingly, D J
1988 "Oil for export? A comparison of Libyan, Spanish, and Tunisian olive oil production in the Roman empire", JRA 1, pp 33-56.

Maxfield, V A and Dobson, M J (eds)
1991 Roman Frontier Studies 1989: Proceedings of the XVth International Congress of Roman Frontier Studies, Canterbury, Exeter: University of Exeter Press.

Maxwell, G S
1983 "Roman settlement in Scotland", in Chapman and Mytum, 1983, pp 233-262.

Meiggs, R
1960 Roman Ostia, Oxford: Clarendon Press.

1982 Trees and Timber in the Ancient Mediterranean World, Oxford: Clarendon Press.

Mercer, R (ed)
1981 Farming Practice in British Prehistory, Edinburgh: Edinburgh University Press.

Middleton, P S
1979 "Army Supply in Roman Gaul: An Hypothesis for Roman Britain", in Burnham and Johnson, 1979, pp 81-98.

Miket, R and Burgess, C
1984 Between and Beyond the Walls, Essays on the Prehistory and History of North Britain in Honour of George Jobey, Edinburgh.

Miles, D (ed)
1982 The Romano-British Countryside, Oxford: BAR:BS 103, volume two.

Miller, D H and Steffen, J O (eds)
1977 The Frontier: comparative studies, Oklahoma: University of Oklahoma.

Millett, M
1984 "Forts and the Origin of Towns: cause or effect?", in Blagg and King, 1984, pp 65-74.

1990 The Romanization of Britain: an essay in Archaeological interpretation, Cambridge: Cambridge University Press.

Millett, M and McGrail, S
1987 "The Archaeology of the Hasholme Logboat", Arch Journ 144, pp 69-155.

Milne, G
1979 "Medieval Riverfront Revetment Construction in London", in McGrail, 1979, pp 145-153.

Mitcalfe, W S
1937 "The History of the Keelmen and their Strike in 1822 ", AA 4.14, pp 1-17.

Mitchell, S
1976 "Requisitioned Transport in the Roman Empire: a New Inscription from Pisidia", JRS 66, pp 106.

Mitford, T
1980 "Cappadocia and Armenia Minor: Historical Setting of the Limes", in Temporini and Haase, 1980, pp 1169-1228.

Mócsy, A
1974 Pannonia and Upper Moesia, London: Routledge and Kegan Paul.

Molin, M
1984 "Quelque considérations sur le chariot des Vendages de Langues", Gallia 42, pp 97-114.

Mommsen, T (ed)
1892 Chronica Minora, Berlin: Gesellschaft fur altere deutsche Geschichtskunde, volume one.

Monaghan, J
1987 The Guernsey Roman Wreck, Guernsey: The Guernsey Maritime Trust.

Moore, G
1954 "Three canal projects, Roman and Byzantine", American Journal of Archaeology 54, pp 97-111.

Moore, P D and Webb, J A
1978 An Illustrated Guide to Pollen Analysis, London: Hodder and Stoughton.

Morisawa, M
1985 Rivers: Form and Process, London and New York: Longman.

Morris, J
1973 The Age of Arthur, London.

Morris, P
1979 Agricultural Buildings in Roman Britain, Oxford: BAR:BS 70.

Mothersole, J
1927 Agricola's Road into Scotland, London: John Lane.

Murray, J A H (ed)
1933 The Oxford English Dictionary, Oxford: Clarendon Press.

Murphy, P
1972 "The charred cereals", in Crummy, 1972, pp 105-10.

Nanson, G C
1986 "Model of Dis-Equilibrium Flood-plain Development", Bulletin of the Geological Society of America 97, pp 1467-1475.

Needham, J
1978 "China and the Invention of the Pound-Lock", Transactions of the Newcomen Society 36, pp 85-108.

Newman, P C
1988 Caesars of the Wilderness, London: Penguin.

Overton, M
1979 "Estimating crop yields from probate inventories: an example from East Anglia", Journal of Economic History 39, pp 363-378.

Palmer, W J
1882 The Tyne and its Tributaries, London: G Bell and Sons.

Partridge, P
1958 Origins, London: Routledge and Kegan Paul.

Passmore, D, Anderson, J D, Macklin, M and Heap, T
1990 Geo-archaeological Investigations of Late Holocene Alluvial Fills and Valley Side Sediments At "Habitancum" Roman Fort, West Woodburn, Northumberland; A Re-Evaluation of the "Piercebridge Formula", Newcastle upon Tyne: Excavation and Field Survey Committee of the University of Newcastle upon Tyne.

Peacock, D P S
1978 "The Rhine and the problem of Gaulish wine into Roman Britain", in Taylor and Cleere, 1978, pp 49-51.

1982 Pottery in the Roman World, London: Longman.

Peacock, D P S (ed)
1977 Pottery and Early Commerce: Characterization and Trade in Roman and Later Ceramics, London: Academic Press.

Peacock, D P S and Williams, D F
1986 Amphorae and the Roman Economy, London: Longman.

Penney, S H
1983 "Romano-British Iron Extraction in North Lancashire", TCWAAS 83, pp 59-62.

Percival, J
1974 The Wheat Plant, London: Duckworth.

Petch, J A
1928 "Excavations at Benwell (Condercum)", AA 4.5, pp 46-74.

Petrikovits, H von
1960 "Das römische Rheinland", Archäologische Forschungen seit 1955 pp 63-72.

Petrovic, P
1968 "The Trajanic inscription at the Iron Gates" Archaeologia Iugoslavia 21, pp 83-91.

Petts, G E and Foster, I D L
1985 Rivers and Landscape, London: Edward Arnold.

Pharr, C
1969 The Theodosian Code and Novels and the Sirmondian Constitutions, New York: Greenwood Press.

Phillips, C W (ed)
1970 The Fenlands in Roman Times, London: Royal Geographical Society Research Series 5.

Piggott, S
1948 "The Excavation at Hownam Rings, Rox", PSAS 82, pp 193-225.
1958 "Native economies and the Roman occupation of north Britain", in Richmond, 1958, pp 1-28.

Pitts, L F and St Joseph, J K
1985 Inchtuthil: The Roman Legionary Fortress, London: Society for the Promotion of Roman Studies, Britannia Monograph Series 6.

Porter, H
1981 "Environmental change in the third century", in King and Henig, 1981, pp 353-362.

Porteous, J D
1977 Canal Ports: The Urban Achievement of the Canal Age, London: Academic Press.

Postan, M M, and Miller, E (eds)
1987 Cambridge Economic History, Cambridge: Cambridge University Press, volume 2, second edition.

Potter, T W
1976 "Valleys and Settlement: some new evidence", World Archaeology 8.2, pp 207-19.

1978 Population hiatus and continuity: the case of the south Etruria survey, London: Elek.

1979 "Romans in North-west England", in TCWAAS Research Series 1, Kendal: Titus Wilson.

Pratt, E
1912 A History of Inland Transport and Communication in England, London: Kegan Paul, Trench Trubner and Co.

Price, J
1978 "Trade in Glass", in Taylor and Cleere, 1978, pp 70-78.

1985 "The Glass", in Bidwell, 1985, pp 206-215.

Price, J and Wilson, P R (eds)
1988 Recent research in Roman Yorkshire, Oxford: BAR:BS 193.

Pryor, A
1978 "The Car Dyke", Dubroviae 6, pp 24-5.

Pucci, G
1983 "Pottery and trade in the Roman period", in Garnsey et al, 1983, pp 105-117.

Raepsaet, G
1979 "La faiblesse de l'attelage antique: la fin d'un mythe?", L'Antique Classique 48.

Ramm, H
1978 The Parisi, London: Duckworth.

Ransom, P J G
1984 The Archaeology of the Transport Revolution, Surrey: World's Work.

Rayment, D L and Pettifer, K
December, 1987 "Examination of durable mortar from Hadrian's Wall", Material Science and Technology 3, pp 997-1004.

Rees, S E
1979 Agricultural implements in prehistoric and Roman Britain, Oxford: BAR:BS 69.

Reece, R
1974 "Numerical Aspects of Roman Coin Hoards in Britain", in Casey and Reece, 1974, pp 78-84.

1981 "The third century: crisis or change", and Henig, volume one, 1981, pp 27-38.

Renfrew, C
1969 "Trade and Culture Processes in European Prehistory", Current Anthropology 10, pp 151-169.

Renfrew, C and Wagstaff, J M (eds)
1982 An island polity: the archaeology of Melos, Cambridge: Cambridge University Press.

Reynolds, P
1979 Iron Age Farm: the Butser Experiment, London: British Museum Publications.

1981 "Deadstock and Livestock", in Mercer, 1981, pp 97-122.

Richmond, I A
1936 "Excavations at High Rochester and Risingham, 1935", AA 4.13, pp 170-198.

1940 "The Romans in Redesdale", in Northumberland County History 15, pp 77-80.

1946 "Part of a stem of a Roman monumental candelabrum", Ant J 36, pp 1-10.

1953 The Roman Fort at South Shields: A Guide, South Shields: South Shields Council.

1954 "Queen Cartimandua", JRS 44, pp 43-52.

1955 Roman Britain, London: Harmondsworth.

Richmond, I A (ed)
1938 Handbook to the Roman Wall, Newcastle upon Tyne: Society of Antiquaries of Newcastle upon Tyne, twelfth edition.

1958 Roman and Native in North Britain, Edinburgh: Nelson.

Richmond, I A and Askew, G
1938 "The Roman Road from High Rochester to the Bridge of Aln", PSAN 8, pp 44-50.

Richmond, I A and Crawford, O G S
1949 "The British Section of the Ravenna Cosmography", Archaeologia 93, pp 1-50.

Richmond, I A and Gillam, J P
1950 "Excavations on the Roman site at Corbridge, 1946-9", AA 4.28, pp 152-201.

1955 "Some Excavations at Corbridge, 1952-54", AA 4.33, pp 218-252.

Richmond, I A, Hodgson, K S, and St Joseph, K
1938 "The Roman fort at Bewcastle", TCWAAS 38, pp 195-213.

Richmond, I A and Hunter-Blair, P
1938 "A Section of the Road at Holystone", PSAN 8, pp 51-2.

Richmond, I A and Romans, T and Wright, R P
1944 "A civilian Bath-house of the Roman Period at Old Durham", AA 4.22, pp 1-21.

Rickman, G
1971 Roman Granaries and Store Buildings, Cambridge: Cambridge University Press.

Rigby, V
1988 "An amphora sherd from the Beadlam Roman villa", in Price and Wilson, 1988, pp 313-21.

Rivet, A L F
1969a "Social and Economic Aspects", in Rivet, 1969b, 173-216.

Rivet, A L F (ed)
1969b The Roman Villa in Britain, London: Routledge and Kegan Paul.

Rivet, A L F and Smith, C
1979 The Place-names of Roman Britain, London: Batsford.

Roberts, N
1989 The Holocene: An Environmental History, Oxford: Blackwell.

Roberts, B, Turner, J and Ward, P
1973 "Recent forest history and land use in Weardale, Northern England", in Birks and West, 1973, pp 207-222.

Robertson, A
1970 "Roman finds from non-Roman sites in Scotland", Brit 1, pp 198-226.

1983 "Roman Coins Found in Scotland 1971-82", PSAS 113, pp 405-48.

Robinson, M A and Lambrick, G H
1984 "Holocene alluviation and hydrology in the upper Thames basin", Nature 308, pp 809-14.

Rodwell, W
1979 "Iron Age and Roman Salt-winning on the Essex Coast", in Burnham and Johnson, 1979, pp 133-175.

Roring, C W
1983 Untersuchungen zu römischen Reisewagen, Koblenz: Koblenz Zentralmuseums.

Rostovtzeff, M
1957 Social and Economic History of the Hellenistic World, Oxford: Clarendon Press, in three volumes.

Rouge, J
1966 Researches sur l'Organisation du Commerce Maritime en Méditerranée sous l'Empire Romain, Paris.

1981 Ships and Fleets of the Ancient Mediterranean, Middleton, USA: Wesleyan University Press.

Royal Commission on Historical Monuments of England
1962 Eburacum, London: HMSO.

Royal Commission on Historical Monuments of Scotland
1956 An Inventory of the Ancient and Historical Monuments of Roxburghshire, Edinburgh: HMSO.

'R.S.'
1675 Avona; or a Transient View of the Benefit of making Rivers of this Kingdom Available. Occasioned by observing the Scituation of the City of Salisbury, upon the Avon, and the consequence of opening that River to that City, ms, Bodleian Library.

Saddington, D B
1980 "British auxiliary regiments - origins and early nomenclature", in Hanson and Keppie, 1980, pp 1071-1076.

St Joseph, Dr
1951 "Air Reconnaissance of North Britain", JRS 41, pp 52-65.

1955 "Air Reconnaissance in Britain 1951-5", JRS 45, pp 82-91.

1961 "Air Reconnaissance in Britain 1958-1960", JRS 51, pp 119-135.

1969 "Air Reconnaissance in Britain 1965-8", JRS 59, pp 104-143.

Salway, P
1958 "Civilians in the Roman frontier region", AA 4.36, pp 227-243.

1965 Frontier People of Roman Britain, Cambridge: Cambridge University Press.

1970 The Fenlands in Roman Times, London: The Royal Geographic Society.

1981 Roman Britain, Oxford: Clarendon Press.

1984 Roman Britain, Oxford: Oxford University Press.

Salzman, L F
1952 Building in England Down to 1540, Oxford: Clarendon Press.

Samuels, J and Buckland, P C
1978 "A Romano-British settlement at Sandtoft, South Humberside", YAJ 50, pp 65-75.

Sarton, G
1959 A History of Science, Hellenistic Science and Culture, Harvard: Harvard University Press.

Savage, H E
1898 "Abbess Hilda's first religious house", AA 2.19, pp 47-75.

Scott, E
1983 "Romano-British Wheat Fields", in Chapman and Mytum, 1983, pp 221-222.

Scott, P R
1977 A Guide to the Visible Remains of Roman Piercebridge, Durham.

1978 "Excavations at Piercebridge, County Durham 1976-1977: Summary Report", University of Durham Archaeological Reports volume 1 for 1977, pp 16-21.

1982 "The Bridges at Piercebridge, County Durham", TAASDN 6, pp 77-82.

forthcoming The Roman Fort, Bridge, and Vicus at Piercebridge, Co. Durham.

Sedgeley, J P
1975 The Roman Milestones of Britain, Oxford: BAR:BS 18.

Selkirk, R
1983 A Dramatic New View of Roman History: The Piercebridge Formula, Cambridge: Patrick Stephens.

1985 "Roman River Navigation - Further Evidence", Popular Archaeology 6.8, pp 32-36.

1986 "River Vessel", Popular Archaeology 6.14, pp 53-58.

1987 A Re-appraisal of the Roman Road system in North-east England, unpublished BA dissertation, University of Newcastle upon Tyne.

1988a "The Long Lost Roman Bridge at Brinkburn", Tyne and Tweed 43, pp 54-58.

1988b "A Bridge 2 Far", Tyne and Tweed 43, pp 42-53.

1989 "The 255 Degree Line", CBA 3, Research Report No. 39, pp 1-13.

forthcoming "The Roman Jetty at Corbridge".

Seltman, C
1953 Greek Coins, London: Methuen.

Shen, H W (ed)
1971 River Mechanics, Fort Collins, CO: Colorado State University.

Sherwin-White, A N
1966 The Letters of Pliny, Oxford: Clarendon Press.

Shotter, D C A
1973 "Numeri Barcariorum: a note on RIB 601", Brit 4, pp 206-9.

Shotton, F W
1978 "Archaeological inferences from the study of alluvium on the lower Severn-Avon valleys", in Limbrey and Evans, 1978, pp 27-31.

Simmons, B B
1975 The Lincolnshire Fens and Fen Edge North of Bourne, University of Leicester: Unpublished MA dissertation.

1979 "The Lincolnshire Car Dyke: navigation or drainage?", Brit 10, pp 183-196.

Singer, C and Homyard, E J and Hall, A R and Williams, T J (eds)
1956 A History of Technology, Oxford: University of Oxford Press, volume two.

Simpson, F G
1967 Watermills and Military Works on Hadrian's Wall: Excavations in Northumberland, 1907-13, Kendal: T Wilson, revised by G Simpson.

Skempton, A W
1953 "The Engineers of the English River Navigations: 1620-1760", Transactions of the Newcomen Society 29, pp 25-54.

Smeaton, J
ca 1776 "Notes on the Lumley Dam", ms Lumley EMC/40/6b, Durham University Library.

Smith, D
ca 1820 Camps and Castles, from Hodgson, 1904, pp 454-455.

Smith, D J
1968 "Two unpublished rakes of Deer Horn", AA 4.46, pp 281-84.

Smith, G H
1977 "Tarraby Lane, Cumbria", Brit 9, pp 19-56.

Smith, N
1971 A History of Dams, London: Peter Davies.

Smith, N A F
1978 "Roman Canals", Transactions of the Newcomen Society 49, pp 75-86.

Smith, P L
1981 Discovering Canals in Britain, Aylesbury: Shire Publications.

Smith, R F
1987 Roadside Settlements in Lowland Roman Britain: a gazetteer and study of their origins, growth and declines in property, boundaries and cemeteries , Oxford: BAR:BS 157.

Spain, C M G
1930 "The treasure vault at the Roman fort at Benwell", AA 4.7, pp 126-130.

Spruytte, J
1983 Early harness systems: experimental studies, London: J A Allen.

Spurr, M S
1986 Arable Cultivation in Roman Italy, London: Society for the Promotion of Roman Studies.

Stanford, S C
1974 Croft Ambrey: excavations carried out for the Woolhope Naturalists' Field Club, Herefordshire 1960-1966, Leominster: published by the author.

Startin, D W A
1982 "Prehistoric Earth-moving", in Case and Whittle, 1982, pp 153-156.

Steer, K
1938 The Archaeology of Roman Durham, University of Durham: Unpublished PhD thesis.

Stephens, C R
1934 "Roman Inscription from Beltingham", AA 4.11, pp 138-145.

Strickland, T J and Davey, P J (ed)
1977 New Evidence for Roman Chester, Liverpool: University of Liverpool, Institute of Extension Studies.

Stuart, P and Bogaers, J E
1971 "Catalogus van de monumenten, Deae Nehalenniae, Gids bij de tentoonstelling Nehalennia de Zeeuwse godin, Zeeland", in de Romeinse tijd, Romeinse monumente uit de oosterschelde, Amsterdam.

Stukeley, W
1757 The Medallic History of Marcus Aurelius Valerius Carausius, Emperor of Britain, London: Baker and Leigh.

Summers, D
1976 The Great Level, Newton Abbot: David and Charles.

Sunter, N J
1976 "The Bridge: a discussion, in The Roman bridge at Aldwincle, Northamptonshire", Brit 7, pp 47-54.

Sutcliffe, J
1795 Report on the Proposed Line of Navigation from Stella to Hexham on the South Side of the River Tyne, with an Estimate of the Expence of Executing the Line, Newcastle upon Tyne: John Bell.

Swan, V G
1984 The Roman Pottery Kilns of Roman Britain, London: Royal Commission on Historical Monuments of England.

Swinbank, B
1953 "Excavations in High House paddock, Northumberland", TCWAAS 2.52, pp 46-54.

Swinburne, J E and Trevelyan, A and Bell, J and Shanks, R
1844 "Notices respecting the Roman Station of Habitancum", Newcastle upon Tyne: T and J Hodgson.

Sykes, J
1833 Local records: or, Historical register of remarkable events, which have occurred in Northumberland and Durham, Newcastle upon Tyne, and Berwick upon Tweed, from the earliest period of authentic record, to the present time, Newcastle upon Tyne: published by subscription.

Syme, R
1958 Tacitus, Oxford: Oxford University Press.

Taylor, C C
1979 Roads and Tracks of Britain, London: Dent.

Taylor, H M and Taylor, J
1965 Anglo-Saxon Architecture, Cambridge: Cambridge University Press, in three volumes.

Taylor, J A
1975 "The role of climatic factors in environmental and cultural changes in prehistoric times", in Evans, Cleere, and Limbrey, 1975, pp 6-19.

Taylor, J A and Cleere, H (eds)
1978 Roman Shipping and Trade: Britain and the Rhine Provinces, London: CBA Research Report 24.

Taylor, M V (ed)
1947 "Roman Britain in 1946", JRS 37, pp 165-182.

1957 "Roman Britain in 1956 I: Sites Explored", JRS 47, pp 198-234.

1955 "Roman Britain in 1954 I: Sites Explored", JRS 45, pp 121-149.

Taylor, M V and Wilson, Dr (eds)
1961 "Roman Britain in 1960 I: Sites Explored", JRS 51, pp 157-190.

Temporini, H (ed)
1974 Aufsteig und Niedergang Der Römischen Welt II.1, Berlin: DeGryter.

Temporini H, and Haase, W (eds)
1980 Aufsteig und Niedergang Der Romischen Welt II Principat, 7.2, Berlin: DeGryter.

Tengstrom, E
1974 Bread for the People, Stockholm: Paul Astroms Forlag.

Testaguzza, O
1964 "The Port of Rome", Arch 17, pp 173-9.

Thomas, A C (ed)
1966 Rural Settlement in Roman Britain, London: CBA Research Report 7.

Thompson, D J
1983 "Nile Grain transport under the Ptolemies", in Garnsey, Hopkins and Whittaker, 1983, pp 64-75.

Thompson, E A
1977 "Britain, A.D 406-410", Brit 8, pp 303-318.

Thompson, F H
1965 Roman Cheshire, Cheshire: Cheshire Community Council.

Thompson, F H (ed)
1980 Archaeology and Coastal Change, London: Society of Antiquaries of London, Occasional Paper, New Series, 1.

Thompson, J
1795 Observations on the Most advantageous Line of Country Through Which A Canal Navigation may be carried from Newcastle upon Tyne, or North Shields, towards Cumberland, with a Proposal to Extend Collateral Branches by the Pont and Blyth Rivers to Morpeth, the Port of Blyth, and the Practicality of carrying a Line of Canal through the Middle of Northumberland to Berwick upon Tweed, Newcastle upon Tyne: R Sands.

Thornes, J B
1987 "The Palaeo-ecology of Erosion", in Wagstaff, 1987, pp 37-55.

Todd, M
1973 The Coritani, London: Duckworth.

Todd, M
1966 "Romano-British Mintages of Antoninus Pius", Numismatic Chronicle 147.

Todd, M (ed)
1989 Research on Roman Britain: 1960-89, London: Society of Antiquaries of London: Britannia Monograph, 11.

Tooley, M J
1980 "Theories of Coastal Change in North-west England", in Thompson, 1980, pp 84-102.

Topping, P
1989a "Early Cultivation in Northumberland and the Borders", PPS 55, pp 161-180.

1989b "The Context of Cord Rig Cultivation in Later Prehistoric England", in Bowden, Mackay, and Topping, 1989, pp 145-171.

Turner, J
1964 "The anthropogenic factor in vegetational history: I, Tregaron and Whixall Mosses", New Phytologist 61, pp 328-341.

1979 "The environment of North-east England during Roman times as shown by pollen analysis", Journal of Archaeological Science 6, pp 285-90.

1981 "The Vegetation", in Jones and Dimbleby, 1981, pp 67-73.

Tyers, P
1978 "The poppy-head beakers of Britain and their relationship to the barbotine decorated vessels of the Rhineland and Switzerland", in Arthur and Marsh, 1978, pp 61-108.

Ulbert, G
1959 "Römische Holzfässer aus Regensburg. Mit einem tiekundlichen. Beiträge von J Boessneck", Bayerische Vorgeschichtsblätter 24, pp 6-29.

van der Veen, M
1987 "Interim report on the plant remains from Tofts Field, Stanwick", in Haselgrove and Turnbull, 1987, pp 13-15.

1988 "Carbonized grain from a Roman granary at South Shields, North-East England", Der Prahistorische Mensch und Seine Umwelt: Forschungen und Berichte zur vor-und Frühgeschichte in Baden-Württemberg 31 pp 1-28.

van der Veen, M and Haselgrove, C C
1983 "Evidence for pre-Roman crops from Coxhoe, County Durham", AA 5.11, pp 23-25.

Venedikov, I
1960 Trakijskata Kolesniza', Sophia.

Verdelis, M E
1957: Oct.19 "How the Ancient Greeks transported ships over the Isthmus of Corinth", Illustrated London News 231, pp 649-651.

Vetters, H and Kandler, M (eds)
1990 Internationalen Limeskongresses 1986 in Carnuntum, Wien: Osterreichische Akademie Der Wissenschaften.

Vita-Finzi, C
1969 The Mediterranean Valleys, Cambridge: Cambridge University Press.

1978 Archaeological Sites in their Setting, London: MacMillan.

Vuorela, I
1986 "Palynological and historical evidence of slash and burn cultivation in Southern Finland", in Behre, 1986, pp 53-64.

Wacher, J
1971 "Yorkshire towns in the fourth century ", in Butler, 1971, pp 165-178.

1975 The Towns of Roman Britain, London: Batsford.

Walker, D
1988 "The Roman Coins", in Cunliffe, 1988, pp 281-358.

Waddelove, A C and Waddelove, E
1990 "Archaeology and Research into Sea-Level During the Roman Era", Brit 21, pp 253-266.

Wagstaff, J M
1987 Landscape and Culture, Oxford: Basil Blackwell.

Walbank, F W
1952 "Trade and Industry under the Later Roman Empire in the West", in Postan and Miller, 1987, pp 74-131.

Wallis, J
1769 The Natural History and Antiquities of Northumberland, Newcastle upon Tyne.

Walton, R H
1962 "The Devil's Causeway and the Bremenium Thrunton Branch Road", HBNC 36.1, pp 53-6.

Ward-Perkins, J B
1962 "Etruscan towns, Roman roads and medieval villages: the historical geography of southern Etruria", Geographical Journal 128, pp 389-405.

Warren, D K and Turner, R M
1975 "Saltcedar Seed Production, Seedling Establishment, and Response to Inundation", Arizona Academy of Science Journal 10, pp 135-144.

Watson, G R
1969 The Roman Soldier, London: Thames and Hudson.

Webster, G
1975 The Cornovii, London: Duckworth.

1988 "Wroxeter", in Webster, 1988, pp 120-144.

Webster, G (ed)
1988 Fortress into City: The consolidation of Roman Britain, First Century AD, London: Batsford.

Webster, P V
1976 "Severn Valley Ware: A Preliminary Study", Trans Bristol Gloucestershire Arch Soc 44, pp 18-46.

Weeks, J
1982 "Roman carpentry joints: adoption and adaptation", in McGrail, 1982, pp 157-168.

Welfare, A
1985 "The Milling-Stones", in Bidwell, 1985, pp 154-164.

Wells, B W
1924 "Trade and Travel in the Roman Empire", Classical Journal 19, pp 7-16.

Wheeler, M
1954 The Stanwick Fortifications, Oxford: Society of Antiquaries of London.

Wheeler, R E M
1929 "The Roman Lighthouse at Dover", Arch Journ 86, pp 29-46.

1943 Maiden Castle, Dorset, London: Society of Antiquaries of London Research Report XII.

Whitaker, T D
1846 Loidis and Elmete: or an attempt to illustrate the districts described in those words by Bede, Leeds and London: Robinson, Son and Holdsworth.

White, K D
1984 Greek and Roman Technology, London: Thames and Hudson.

Whitwell, J B
1982 The Coritani, Oxford: BAR:BS 99.

Whitworth, R
1797a Report on the Proposed Line of Navigation from Stella to Hexham and from Hexham to Haydon-Bridge, on the South Side of the River Tyne, Newcastle upon Tyne: J Bell.

1797b Report on the Proposed Canal on the North Side of the River Tyne, with Observations on that Report; Together with various Publications and Petitions for and against that line of canal, Newcastle upon Tyne: J Whitfield.

Wild, J P
1965 "A Roman silk damask from Kent", Archaeol Cantiana 80, pp 246-50.

1970 Textile Manufacture in the Northern Roman Provinces, Cambridge: Cambridge University Press.

1978 "Cross-Channel trade and the textile industry", in Taylor and Cleere, 1978, pp 79-82.

1979 "Roman and Native in Textile Technology", in Burnham and Johnson, 1979, pp 123-131.

Wilkes, J J
1960 "Excavations in Housesteads fort, 1959", AA 4.38, pp 61-72.

Will, E L
1977 "The ancient commericial amphorae", Archaeology 30, pp 264-70.

Willan, T S
1964 River Navigation in England, London: F Cass.

Willcox, G
1977 "Exotic plants from water-logged sites in London", Journal of Archaeological Science 4, pp 269-282.

Williams, D
1983 "The Vallum's Original Intention: a Multi-Purpose Work of Frontier Support", TCWAAS 83, pp 33-39.

Williams, D F, and Peacock, D P S
1983 "The importation of olive oil into Iron Age and Roman Britain", in Blazquez and Remesal, 1983, pp 263-80.

Wilmot, T
1982 "Excavations at Queen Street, city of London, 1953 and 1960, and Roman timber-lined wells in London", Transactions of the London Middlesex Archaeological Society 33, pp 1-78.

Wilson, D
1983 "Pollen analysis and settlement archaeology in the first millenium BC from north-east England", in Chapman and Mytum, 1983, pp 29-53.

Wilson, D M
1976 The Archaeology of Anglo-Saxon England, London: Methuen and Co. Ltd.

Wilson, D R
1967 Roman Frontiers of Britain - Regional Archaeologies, London: Heinemann.

Wilson, P R, Jones, R F J, Evans, D M (eds)
1984 Settlement and Society in the Roman North, Bradford and York: School of Archaeological Sciences, University of Bradford; Yorkshire Archaeological Society.

Wolman, M G and Leopold, L B
1957 River Flood Plains: Some observations on their formation, New York: US Geological Survey, Prof Paper 282-C.

Woodfield, C C and Chaplin, R E
1965 "Six turrets on Hadrian's Wall", AA 4.43, pp 87-200.

Woof, V
1986 Later Prehistoric and Romano-British Settlement and Agriculture in the Tyne-Forth Province: A Review of Recent Work, unpublished MA dissertation, University of Newcastle upon Tyne.

Wooler, E
1917 The Roman Fort at Piercebridge, London: Butler and Tauner.

Woolley, C L
1907 "Corstopitum: Provisional Report of the Excavations in 1906", AA 3.3, pp 161-186.

Woolliscroft, D J
1989 "Signalling and the Design of Hadrian's Wall", AA 5.17, pp 5-19.

Wright, R P
1938 "The South-western sector of the Devil's Causeway", AA 4.15, pp 351-361.

1940a "The Devil's Causeway from Rimside Moor (Longframlington) to the Bridge of Aln", AA 4.17 pp 65-74.

1940b "The Wreckendike and Roman road-junction on Gateshead Fell", AA 4.17, pp 194-209.

1944 "The establishment of the fort at Chester-le-Street in AD 216", AA 4.22, pp 83-90.

Wright, R P and Gillam, J P
1951 "Second Report on Roman Buildings at Old Durham", AA 4.24, pp 203-12.

Wright and Wright
1965 "The Boats from North Ferriby, Yorkshire, England", Proceedings of the Historical Society 31, pp 18-24.

Yarranton, A
1677-81 England's Improvement by sea and land, London: R Everingham.

Yeo, C A
1946 "Land and Sea Transport in Imperial Italy", Transactions of the American Philological Society 77, pp 221-44.